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ORAL PRESENTATIONS

TOPIC 2. WMSDs Work related Musculoskeletal Disorders

An Assessment of Stooped Postures During Manual Weeding Tasks and Recommendations for Managing Work Practices

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Keywords: Low back injury, agriculture, weeding exposure assessment

Objectives

Feeding the world involves significant manual labor, with the majority of work performed by migrant workers. Vegetable production involves work tasks that often expose farm workers to extreme and awkward trunk positions (e.g., stooping, squatting, kneeling postures). New laws recently passed in the US State of Colorado, have banned the use of short-handled weeding hoes and have limited workers to 8 hours per week of manual weeding. Unfortunately, the new state laws restricting weeding tasks do not define stooped postures nor do they provide information for farm owners on how to measure the time in stooped postures. The purpose of this study was to define stopped postures, develop methods to quantify time spent in stooped postures, and develop management practices to address stooped postures during manual weeding.

Methods

Farm workers were recruited from farms in the US State of Colorado. Participants wore an accelerometer-based trunk motion logging system while manually weeding and harvesting a variety of produce. The magnitude, frequency, and time spent in three categories of trunk postures during weeding and harvesting tasks were assessed.

Results

Low back postures of 48 farmworkers were assessed during manual weeding, and manual harvesting of cilantro, spinach, zucchini, and corn harvesting. The majority of harvesting tasks involved a high percentage of time spent in trunk postures greater than 60 degrees of trunk flexion (stooped posture). Manual weeding involved less time spent in stooped postures and was dependent on soil and weed conditions. The frequency and duration of time in a stooped posture varied by product harvested and by pay incentives. Smaller produce and produce grown closer to the ground generally involved a greater amount of time in a stooped posture. Pay incentives based on production were associated with significantly longer times in stooped postures for workers. Quantifying stooped postures among farm workers can be used to assess, develop and manage improved work designs that reduce the risk of low back stress during agricultural tasks.

The Use of Exoskeletons in Daily Agricultural Work Processes

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Keywords: Muscular-skeletal disorders (MSD), livestock, horticulture, implementation of new technology, employee participation

Objectives

What are the perspectives in introducing exoskeletons in agriculture and horticulture?
According to scientists and producers, the externally worn skeletons can reduce up to 80% of the workload, depending on the design and the occupational task. But what are the gains and difficulties in agriculture, and do we have any experiences so far?

Methods

In the milk barn, the pig barn or in handling sacks of feeding supplements, the farm employee suffers physical stress and continuant harmful work positions. 40 pct. of the reported occupational diseases in Danish agriculture was in 2019 due to MSD, muscular skeletal disorders. That's compared to 32 pct for the entire Danish labour market, with an unknown amount of underreporting of these type diseases among farmers.

Experiences have been collected across farms and horticultural businesses in Denmark that have taken first steps to implement exoskeletons into the core work processes of agriculture – milking, mending of new-born piglets, sorting the 7 to 10 kilos piglet and other daily routines such as feed-ing and continuous handling of various burdens.

Results

In Denmark some farmers are already moving forward into this next era of manual work methods, heavily motivated by their own experiences with low back pain or shoulder disorders, and by growing problems with attracting and keeping the needed staff. Latest updates from several farms will be included in the presentation.

Putting new 'gadgets' like exoskeletons into an environment of old habits such as a dairy farm or pork production should call for consideration and thorough preparation. Although the gain of less painful workdays sounds attractive, new ways are not often easy to adopt. Experiences with employee participation will be shared and discussed in comparison with theories used in general health promotion and nudging tools.

Introduction of Passive Trunk Supporting Exoskeletons on an Asparagus Farm

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Keywords: MSD, occupational injuries, back support, agriculture, PPE

Objectives

Agriculture is recognized as one of the most hazardous industries worldwide, with musculoskeletal disorders (MSDs) being among the most frequent workplace injuries. Exposure to awkward postures and lifting of heavy loads are part of the daily work routine of agricultural workers in general and especially in asparagus production. Passive trunk-supporting exoskeletons have entered the market of assistive technologies and are able to reduce musculoskeletal loads, thus implementation in agriculture seems promising. Several studies of first implementation in agriculture showed, that there are success but also failure factors for technology adoption and long-term trials in agriculture are lacking completely. The aim of this study is to record the satisfaction, exhaustion and pain perception of people who wear an exoskeleton during work over a longer period of time.

Methods

After a 3-week test period where selected workers can voluntarily use an exoskeleton, each participant fills in a daily questionnaire to estimate daily satisfaction/dissatisfaction, fatigue and the prevalence of pain. At the end of the trial, the participating workers will be interviewed.

Results

The results of the daily questionnaires will be presented and discussed.

Whole Body Vibration Exposure in Olive Harvesting by Means of Tractor-Mounted Harvesters: A Case Study

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Keywords: Vibration, tractor, olive harvester, exposure, health

Objectives

The aim of this paper is to evaluate the effect of Whole-Body-Vibrations (WBV) in tractor-driving farmers during the activities of olive harvesting by means of tractor-mounted harvesters. More specifically the focus of the work consists in highlighting the influence of the different work phases on WBV's exposure.

Methods

In order to obtain information regarding exposure levels, an experimental campaign was realized in a farm. A vibration dose was calculated by assigning each vehicle driven a vibration magnitude, estimated on the base of vibration measurement. The measurement was performed with two male tractor drivers, on different workstations and with different positions of the machine's shaking arm. The first workstation is that of the tractor driver, while the second one is located in correspondence of the seat supplied with the machine for the workers assigned to move the mechanical arm so as to shake tree branches. In order to characterize the phenomenon, the measurements were carried out with different inclinations and lengths of the shaking arm.

Results

The root mean square accelerations (r.m.s.) were calculated for the vibrations measured in both seats and under different conditions. The results highlight the different levels of exposure of the two operators during the activities. Furthermore, the data show that the mechanized movement of the arm greatly influences accelerations because it generates high stresses especially in the maximum extension with respect to the source signal produced by the tractor engine.

ORAL PRESENTATIONS

TOPIC 3. Machine Milking, Animal Welfare, Sustainable livestock farming

Effect of Automatic Feeding System on Feeding Behaviour and Agonistic Interactions at the Headlock in Dairy Cows

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Keywords: Animal welfare, feeding, behaviour, automation, dairy cow

Objectives

The introduction of Automatic Feeding Systems (AFS) reduces farmers' work and makes it flexible, increases animal welfare and reduces feed competition. The frequent passing of AFS and the constant presence of fresh feed, reduces the voracity of the dominant cows and the waiting stress of the submissive ones. The aim of this study was to evaluate the response of the animals to AFS, the behaviour of the animals in the headlock was observed. In particular, the number of animals present at the headlock and the number of agonistic interactions manifested during the distribution and approach phases were recorded.

Methods

The study was carried out between August 2021 and December 2022 and involved 4 dairy farms: two farms with traditional feed distribution and approach (A e B); one with traditional feed distribution and automatic approach system, using a push feed robot (C); one with AFS (D). Trained operators carried out 8 surveys per farm, two for each season, by direct observation during and after the feed distribution phases. The survey began about 5 to 10 minutes before distribution and lasted about 5 hours. This observation period allowed at least 1 distribution and 1 approach to be observed on each farm. Data were analysed using a descriptive statistic.

Results

Attendance (the number of animals present at the headlock) is expressed as the percentage of cows in the headlock out of the total number of cows in the group, while agonistic behaviour is expressed as the percentage of agonistic interactions out of the number of cows in the headlock at that time. The present results show that the percentage of animals present at the headlock in farm A (34,06%) is higher at the time of distribution than in farm D (15,01%). In addition, the presence of AFS in farm D limits the number of agonistic interactions at the time of distribution (10.57%), a percentage that remains almost constant in the approach phase (9.76%). The present data show that AFS may be a solution for reducing feed competition and increasing cows welfare, particularly of the ones occupying lower positions in the social hierarchy.

Efficient Use of Artificial Lighting and Intensive Use of Natural Light in Milking Parlours: the MUNGILUX Project

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Keywords: Milking parlours, artificial and natural lighting, illuminance, lighting design

Objectives

Milking is a crucial phase in milk production. In modern dairy farms it is carried out in specific milking parlours where cows are milked in groups at fixed times. Celozzi et al. (2021) conducted a study regarding milking performance and microclimatic conditions of dairy farms that highlighted milking parlour as the area with the worst light intensity during the whole day in the different seasons (winter and summer). Tangorra and Costa (2022), in a study aimed to assess the milking parlour lighting during a milking session, found light power density $< 6 \text{ W/m}^2$, while only 20 % of the analysed milking parlours had illuminance and illuminance uniformity compatible with the standard (UNI EN 12464/1, 2011) of 200 lx and 0.6 respectively.

Various researchers (Rajaniemi et al., 2015; Clarke and House, 2016) recommend milking parlour lighting intensities of 200-250 lx, in line with Harner and Smith (2008) who suggest lighting levels of 215 lx. The American Society of Agricultural and Biological Engineers (ASABE, 2014) advises the importance of lighting the milking pit, recommending values of 500 lx to ensure adequate lighting for checking udder hygiene, milk alterations and attaching milking clusters.

The objectives of the project are to study and improve milking parlour lighting by implementing alternative, energy-saving and low-cost lighting solutions to illuminate properly the milker's visual task area. The research hypothesis is that ensuring adequate lighting for humans and animals can increase labour productivity and work safety, improve the hygienic-sanitary management of cows, increase milk quality, and reduce energy consumption with a greater economic and environmental sustainability of the whole production process.

Methods

An innovative methodological approach, based on the use of a lighting design software (Dialux) will be implemented to improve the lighting of the milker's visual task area and the area immediately surrounding it. The following steps will be carried out:

Milking parlour digital modelling, with the layout of glazed surfaces and luminaires, and the creation of external scenarios to assess any obstacles obstructing the entrance of natural light;

Simulation of the milking parlour illuminance values by the lighting design software and assessing their compatibility with the reference technical standard UNI EN 12464/1 (2011). In case of non-compatibility, low cost and energy saving artificial lighting solutions useful to adapt the lighting level to the standard will be identified. On the other hand, if the regulatory requirements are met, alternative

artificial lighting solutions that guarantee greater energy savings will be considered. In both cases, evaluation of systems to enhance and make more uniform natural lighting;
Estimation of the energy consumption of the lighting solutions based on LENI (Lighting Energy Numeric Indicator, kWh/m²) and calculation of the payback time;
Quantification of the direct and indirect benefits achievable with milking parlour lighting optimisation.

Results

Expected results are the following:

1. Providing a method to objectively evaluate the lighting conditions of existing milking parlours and to simulate improvements to the lighting system in terms of energy saving and visual comfort;
2. Generating alternative lighting scenarios and quantifying their energy consumption and payback time allowing better investment;
3. Defining guidelines to properly manage milking parlour lighting with the aim of improving the visibility of the milkers' area of responsibility in order to: guarantee hygienic and safe working conditions; increase the effectiveness of pre-milking activities; reduce the possibility of accidents and fatigue that can lead to chronic problems; improve the quality and productivity of work; reduce animal stress in all milking related activities.

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An Innovative Indoor and Controlled Sustainable Snail Breeding System

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Keywords: Soilless system, greenhouse, snail, heliciculture, burr

Objectives

In recent years, the consumption of snails has grown throughout Europe, especially in the Mediterranean countries. This work aims to prototype snail farming based on vertical panel farming modules, also called "Stackable Modular Cells" registered at the Italian Patent and Trademark Office. Experimentation and research aimed at analysing and studying the efficiency of this indoor and controlled farming system compared to the outdoor one.

Methods

Experimentation concentrates on breeding *Helix aspersa müller* and *Helix aspersa maxima*. The innovation is represented by the climate-controlled environment that allows for recreating the ideal environmental conditions for the growth of the snails. It is guaranteeing healthy and economically viable production, too.

The prototype system is a greenhouse that covers an area of approx. 100 m² for each experimental plant. A fundamental element of this system is the "cell", which consists of raised floors where the snails are raised. It contains a series of plastic material panels, which hang vertically from metal support and aim to increase the useful breeding area. The cells can be stacked on two or more floors in a receiving structure called a "module", at the base of which there is an anti-escape metal grating. Each cell is served by water and electricity systems necessary to control the humidity level and the duration of the photoperiod (alternating light/darkness).

Results

The advantages that this breeding system offers compared to traditional breeding systems are the best hygienic-sanitary conditions, shortening of the production cycle, programming, control, and water saving.

With the controlled climate indoors breeding method, being able to determine exactly the type of feeding to be administered and the climatic conditions of breeding, it is possible to obtain a burr with constant qualitative characteristics, which guarantee the creation of a new certifiable "product", in the quality and in the active principles possessed.

Relationship Between Heavy Metals Concentration Detected on Honeybees and Their Activity Level

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Keywords: Honeybees, heavy metals, environmental indicator, activity index

Objectives

Honeybees farming is spread all over in the world, and it is essentially practiced as small-scale farming, experienced not only in rural areas, but nowadays also in urban and suburban sites. Honeybee colonies losses depend mainly on pests and diseases, as the fungal Nosemosis and the parasitic Varroasis [1], able to cause losses all over the world [2]. In the last times, the decline of pollinators is worsened by the loss of forage caused by the intensification in agriculture [3], and by the increase of environmental contaminants, as heavy metals. Heavy metals, emitted in the environment by natural and anthropic sources, increased rapidly over the past century for the enhanced anthropogenic emissions into the environment [4], leading to high metals concentrations in the atmosphere and to accumulation on plants, on nectar and pollen, that represent the feed picked up by honeybees during foraging [5]. Moreover, the use of slurry and manure for agronomic purposes release metals on field, repeated fungicide application can contaminate plants with metals [6], inducing a chemical and environmental impairment. In this research, bees were taken into consideration for their important pollination action responsible of the propagation of about 80% of plants, essential for survival on the planet, and for their role of environmental indicator [7]. Specifically, the study evaluated the ability of honeybees as bioindicators of atmospheric heavy metals, comparing the concentrations detected on them with their activity level, from Springtime to Autumn.

Methods

The research involved two apiaries, each composed of four hives, located in the province of Lodi. One apiary was located in San Fereolo, a periurban location of Lodi and the second one in Comazzo, a rural zone near the TEMM highway, connecting the south of Milano to Brescia. Two hives for location, were equipped with a monitoring system (Melixa, Trento), able of recording the activity index of the bees (the number of flight), the variation in weight of the colonies and the climatic situation, inside and outside the hive.

During three seasons of sampling, three samples of adult bees for each hive, were collected, to analyze the presence of 26 heavy metals: Sn, As, Cd, Cr, Cu, Fe, Hg, Mn, Ni, Pb, Mg, Sn, Th, Na, K, Ca, Sr, Se, Tl, V, Al, Ag, Co, Mo, Sb, U. The chemical analyzes for the detection of metals on bees were carried out by the IZS, Experimental Zooprophyllactic Institute of Lombardy and Emilia-Romagna, Bologna. Samples were analyzed by inductively coupled plasma mass spectrometry (ICP/MS). The

data thus obtained were processed using the analysis of variance (Proc GLM) of the SAS 9.4 statistical package, to evaluate the effect of the site (peri-urban and biodiverse - San FereOrto- vs agricultural - Rossate) on the concentration of metals found on bees and on their activity level, considering the sampling phase, the climatic conditions and variation of colonies weight.

Results

In general, the bees of San Fereolo showed lower values of metals than the colonies of Rossate, except for Mercury (0.004 mg kg^{-1} vs 0.010 mg kg^{-1} , $P < 0.001$), Arsenic (0.017 mg kg^{-1} vs 0.024 mg kg^{-1} , $P < 0.05$) and Selenium (0.032 mg kg^{-1} vs 0.048 mg kg^{-1} , $P < 0.01$). In particular, some metals of extreme importance for the survival of the bee colonies such as Zinc, Lead and Copper are significantly higher in Rossate, an agricultural site close to the TEMM highway, a factor which probably favoured the rise of these concentrations on the colonies, together with a higher activity level ($P < 0.05$), probably for a greater foraging activity and pick up of nutrients towards other sites. The San Fereolo bees, reared in a more «biodiverse» site, are characterized by a lower bee activity index, by general lower metals mean concentrations, but by a higher concentration of Selenium and Mercury, metals responsible for hypoactivity and sub-lethality of the colonies. In conclusion, the results show us a positive situation and a reduction of the load of metals on bees, in line with the literature [7], and they confirm the ability of bees as environmental indicators of pollutants.

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Ammonia Remediation in Recirculating Aquaculture Systems: Photocatalysis vs Electro-Photocatalysis

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Keywords: Water remediation, photo-electrocatalysis, rainbow trout, ammonia, welfare markers

Objectives

The major challenges in aquaculture are the generation of waste and water pollution. These issues can lead to an increased risk of diseases among the reared species, posing a threat to biodiversity and human health [1].

In aquaculture there are various remediation methods that can be adopted to remove ammonia, produced by fish and by uneaten food from water ecosystems [2]. The traditional process of bacterial nitrification is considered highly efficient, in fact biological filtration systems are the most widespread. However, due to its multiple limitations, the development of a novel approach to enhance water quality is needed. Photocatalysis (PC) is a low-cost, and environmentally friendly method for converting ammonia present in water to nontoxic molecular nitrogen molecules [3]. In recent times, PC was compared [4] to photo-electro-catalysis (PEC), based on the application of an external electrical bias between the photocatalyst deposited as a thin film on a conductive support (acting as photoanode), and a suitable counter electrode (cathode), able to boost the conversion of ammonia to molecular nitrogen.

This experimental study aims to determine the effect of photocatalysis (PC) and photo-electrocatalysis (PEC) on the transformation of ammonia into non-toxic molecular nitrogen (gaseous N₂) in a rainbow trout (*Oncorhynchus mykiss*) recirculating water system by comparing three tanks equipped with the biological filter and the photocatalytic-electrophotocatalytic system (treatment) to three tanks equipped only with the biological purification system (control).

Methods

The trial was divided into three stages: the first stage (T0) lasted 30 days for biofilters maturation. In the second stage (T1-T2), the fish were housed in tanks and the system was operating in photocatalytic mode. In the third phase (T3), lasting till the end of the trial, the system was switched to photoelectrocatalysis (PEC) investigation. A multidisciplinary approach was also employed to analyse the influence of treated water on the health of *O. mykiss* in order to determine the response to environmental stress on both physiological and molecular levels, through histological methods and a Real Time PCR approach.

Results

Total ammonia nitrogen (TAN) production in the treatment tanks was subjected to photoinduced oxidation on the photocatalyst surface.

The experimental tanks water exhibited a faster abatement and a smaller mean concentration of NH_3 in the three phases, with 2.03 mg/L vs. 2.06 mg/L (T0–T1, i.e., during the biological filter maturation), 2.26 mg/L vs. 2.37 mg/L (T1–T2, i.e., during the photocatalytic treatment) and 1.13 mg/L vs. 0.11 mg/L (T2–T3, i.e., during the PEC treatment; $p < 0.01$) in control and treated tanks, respectively.

NO_2 - concentrations were lowered during the PEC phase, perhaps due to TAN oxidation carried out by photoelectrocatalysis, which resulted in gaseous nitrogen. The reduced level of nitrite, which are extremely hazardous to fish survival, in the treated tanks is an encouraging finding. The increased nitrate level in the PEC system is insignificant since fish are not exposed to harmful NO_3 - concentrations.

Fish welfare was improved by PC - PEC reactors, with a better expression of the oxidative stress markers SOD1, GPx1 and GR in the liver of fish at T3, suggesting a higher oxidative stress exposure in the control group [5]. In general, significant lower levels of oxidative stress markers and inflammation parameters (TNF α) gene expression [6] were found according to PC – PEC treatment.

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Vertical Profile of Noxious Gas Concentrations in an Open Dairy Barn in Mediterranean Area

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Keywords: Ammonia, methane, carbon dioxide, environmental monitoring, livestock production

Objectives

The aim of the study was to investigate the vertical profile of ammonia (NH₃), methane (CH₄) and carbon dioxide (CO₂) at different sampling locations (SLs) at the centre of an open dairy barn located in the Mediterranean area.

Methods

The experiment was carried out in a cubicle free-stall dairy barn equipped with fans, located in Sicily (Italy). The photo-acoustic spectroscopy was applied to record NH₃, CH₄ and CO₂ at 3 SLs. The SLs were vertically distributed at the centre of the barn. Gas concentrations at different heights (i.e. SLA, SLB and SLC at 0.40 m, 1.50 m and 2.70 m, respectively) from the floor were organised in a dataset and statistical analyses were carried out to identify differences in gas concentration profile between gases. Data were examined by using the one-way analysis of variance (ANOVA), correlation analysis and regression analysis.

Results

The vertical profile of gas concentrations shows significant differences between gases ($P < 0.001$). The highest values for NH₃ and CH₄ were recorded at 0.40 m and 2.70 m from the floor, respectively. The correlation coefficient between NH₃ at SLB and NH₃ at SLC, CH₄ at SLC and CO₂ at SLC, and CH₄ at SLC and NH₃ at SLC was 0.67 on average. Based on the regression analysis, the R-squared adj between NH₃ at SLB and NH₃ at SLC as well as CO₂ at SLC and CH₄ at SLC was higher than 40% with $P < 0.05$.

ORAL PRESENTATIONS

TOPIC 5. Instrumentation, Equipment, Periodic Procedures and Tests

Using a Low-Cost Portable Device to Assess Bergamot Fruit Colour in the Field

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Keywords: Fantastico, citrus colour index, portable device

Objectives

Bergamot (*Citrus bergamia*, Risso et Poiteau) is a citrus fruit cultivated in a narrow coastal strip of about 150 km in the province of Reggio Calabria (southern Italy). It is used in various sectors, including medicine, cosmetics, perfumery and the food industry. Having regard to this, the purpose of this work is to present the intermediate results of an ongoing industrial doctoral thesis, in the framework of the National Operative Program PON Research and Innovation 2014-2020 funded by the Italian Ministry of Research. Particularly, the paper deals with the assessment of bergamot fruit colour in the field using a low-cost portable device instead of conventional analytical instruments to determine the optimal ripening stage.

Methods

Sampling considered different batches of bergamot fruit picked at different ripening stages. Bergamot images were acquired using a mobile device equipped with a portable black chamber. On the other hand, bergamot fruit colour was also measured using the portable spectrophotometer Konica Minolta, model CM-700d, previously calibrated, to obtain colour characteristics in the HunterLab space, and subsequently calculate the Citrus Colour Index (CCI).

Results

Bergamot fruits were classified with high accuracy according to the criteria mentioned above.

ORAL PRESENTATIONS

TOPIC 7. Agriculture 4.0, Automation, Remote Control, Robot and Innovative Vehicle

Development of a Prototype of a Self-Driving Electric Vehicle: the MAGA Project

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Keywords: Greenhouse robot, electrification, protected cultivation, sprayer

Objectives

In recent years, agricultural robotics has received great attention in research studies, being considered a way to address some important issues of the agricultural sector, such as precision agriculture, resource saving, improvement of safety conditions and shortage of human labour. These issues are particularly relevant in greenhouse production systems where many highly repetitive and sometimes dangerous operations still require to be performed by humans. In this context, the Piedmont Region (North-western Italy), thanks to European funds for regional development, sponsored and supported the MAGA project based on the creation and development of a self-driving electric machine able to perform several agricultural operations in the greenhouse environment.

Methods

The project involves both industrial and academic partners: Smartec srl, the project leader, focusing on the design, construction and production of advanced electronic systems and CNR-STEMS, drawing its attention on assessing the system sustainability and promoting the advancement and dissemination of knowledge and technologies.

The project activity was divided into three main tasks:

1. Prototype design and realization;
2. Preliminary tests in an experimental environment;
3. Tests in a real working environment.

Results

MAGA developed a multipurpose agricultural vehicle with specific characteristics: self-driving; mobility on different grounds; able to sprayer agrochemicals and collaborative ability with operators during greenhouse operations (harvesting, transport, etc.). >Finally project framework, results and future implications are discussed.

Design of Manure Spreader Wagon for Sewage Sludge's Precision Distribution

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Keywords: Biosolids, variable rate technology, organic fertilization

Objectives

In Italy, sewage sludge use in agriculture is a controversial practice. On the one hand, there are the benefits that sludge brings to the soil and crops (e.g., organic matter, nitrogen, etc...), and on the other hand, the risks associated with the potential pollution from heavy metals and microplastics. The use of precision agriculture, specifically variable rate technology (VRT), can bring improvements and benefits to the soil, crop and environment.

Methods

Thanks to the support of external know-how, the research group developed a manure spreader wagon to distribute civil sewage sludge through VRT techniques. The technological implementation, carried out on a usual manure spreader wagon, is characterized by the following elements: i) Advancement sensor of the lower belt of the wagon; ii) load cells for the control of the distributed dose; iii) ISOBUS connector. The tractor requires a GPS receiver and an onboard computer for wagon control and management.

The distribution occurred on the paddy soil of a rice farm in Basiglio (MI). Before sewage distribution, the land under test underwent soil geoelectric scanning to create the prescription map. Two white zones are left to test the responsiveness of the spreader.

Results

The distribution started in areas with a prescribed high dose of sewage sludge. The rear bulkhead of the wagon was always open to the maximum height. The spreader correctly distributed the product along the field, perfectly respecting the transitions from high-dose to low-dose areas and vice versa. In the two reference zones defined as "white", the distribution stopped correctly. The data collected during distribution was correctly stored in the onboard computer and subsequently downloaded by the operator via USB.

This developed distribution system promises to be an excellent solution for managing sewage sludge to exploit its soil fertilizing and conditioning potential at most. Furthermore, it is an excellent solution to increase environmental sustainability.

A Survey on the Current Legislation to Safety Use of Drones in Agriculture

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Keywords: Unmanned aircraft systems, remote pilots, airworthiness, rules concerning unmanned aircraft

Objectives

Drones or unmanned aerial vehicles for agriculture are proximity aerial survey tools for precision agriculture. As is known, these unmanned aerial vehicles if equipped with visible, multispectral, and thermal sensors, can quickly provide maps on the state of the crops. Although in Italy yet not used, drones for agriculture are also useful for the targeted, ecological, and economic low-altitude aerial distribution of products. Really, it is possible to distribute liquid products, granules, powders, and capsules automatically and precisely from above. Furthermore, through specially programmed automatic flights, it is possible to make rapid surveys even on terrains that are difficult to reach by human operators. In this context, the current legislation regulating the flight of drones for agricultural purposes has been investigated with the aim to assess the risk and safety condition of both the drone driving operator and the drone itself.

Methods

As is known, the use of drones for operations in the agricultural sector is subject to the Implementing Regulation (EU) 2019/947, which has undergone subsequent amendments and additions. This regulation was taken over by the Italian Civil Aviation Authority (ENAC) which integrated it with national provisions. Other current codes are also referred to by the ENAC regulation which affect the procedures for the operation of unmanned aircraft. The purpose of this paper is to exhaustively summarize the articulated aspects of the current legislation relating to the procedures for the operations of unmanned aircraft used in the agricultural sector. The planning of a drone flight to carry out remote sensing in an agricultural field and the related risk analysis will be described as an example.

Results

It should be considered that unmanned aircraft technologies allow for a wide range of possible operations and to ensure the safety of people on the ground during unmanned aircraft operations, requirements relating to airworthiness and the persons involved in the operation should be established of the UAS. Furthermore, the use of drones to perform remote sensing in agriculture belongs to the "open" category. This category covers operations that present the lowest risk. Conversely, the use of drones for the distribution of products, such as granules, powders, and capsules, falls into the "specific" category. This category covers the types of operations presenting a high risk and for which a thorough risk assessment should be carried out to point out which requirements are necessary to keep the operation safe.

A Functional Classification for Agricultural Robots

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Keywords: Robotics safety, agricultural robotics, operational management, precision agriculture

Objectives

Agricultural robotics is gaining more attention as a potential solution to increase efficiency and productivity in the agricultural sector. This is in response to a growing global population and an increase in the demand for food. The size of the global market for agricultural robotics is projected to reach USD 17.8 billion by 2027 (Research and Markets, 2022). Additionally, the report highlights the fact that the increasing adoption of automation and robotics in agriculture is driven by the necessity for sustainable farming practices, labour shortages, and the rising demand for food.

In the recent years, there has been significant research and development in the field of agricultural robotics, with innovations ranging from drones and sensors for crop monitoring to autonomous tractors and harvesters. These technologies have the potential to completely change the way farming is done by decreasing the amount of money spent on labour, raising productivity levels, and enhancing crop yields (Lowenberg-DeBoer et al., 2020). The rising number of robots available on the market require a classification in order to allow final users to identify the most suitable solution for their needs. In this paper a functional classification is proposed.

Methods

A dataset of more than 100 agricultural robots was composed by analysing the dataset provided by the company. Such dataset contains information about weight, powertrain features, power, safety sensors, guidance system, and several other features of agricultural robots. A clustering algorithm was then applied in order to provide a multivariate classification based on different robots' features. The resulting classes were then characterized according to their mean and standard deviation.

Results

The classification of agricultural robots that is proposed in this paper identifies four primary classes of agricultural robots, which differ from one another in the characteristics of their powertrains and their weight-to-power ratios. In three classes, the weight-to-power ratio is greater than in conventional agricultural tractors.

Reference

Lowenberg-DeBoer, J., Huang, I. Y., Grigoriadis, V., & Blackmore, S. (2020). Economics of robots and automation in field crop production. *Precision Agriculture*, 21(2), 278–299. <https://doi.org/10.1007/s11119-019-09667-5>

Research and Markets. (2022). *Agricultural Robots Market: Global Industry Trends, Share, Size, Growth, Opportunity and Forecast 2022-2027*.

Comparing the Performance of Traditional and Autonomous Tractors in Maize Sowing: An Overall Evaluation of Agricultural Robot Adoption

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Keywords: Agricultural robots, UGV, machine operating efficiency, precision farming

Objectives

Over the past few decades, robots have increasingly been used in agriculture to automate various tasks, from planting and harvesting crops to monitoring crop health. These robots are designed to increase efficiency, reduce labour costs, and improve crop yields while minimising environmental impact. Some examples of agricultural robots include autonomous tractors, drones equipped with sensors and cameras, and robotic arms for precision planting and harvesting. The use of robots in agriculture is a rapidly growing field. It is expected to continue to expand in the coming years as the demand for sustainable and efficient farming practices increases.

This research aims to compare the performance of a traditional tractor with an autonomous tractor in terms of time needed to perform the same task, evaluating machine operating performance using effective working times and accessory times (turns and downtime).

Moreover, focuses on the overall evaluation of the adoption of this new technology, considering every aspect, from the knowledge required to operate the robot to the final working operation, considering pros, cons and all the obstacles encountered in the robot setup.

Methods

The comparison was performed between maize sowing, using a traditional tractor (Lamborghini R4.95) equipped with Monosem NG Plus 4 rows planter (working width 3m) and an autonomous tractor (Robotti 150d) equipped with Mascar three rows planter (working width 2.10). The operating speed was 7 km/h for the tractor and 5 km/h for the robot. The operations were executed in the same field, divided into eight blocks, four for the tractor and four for the robot. The times were collected by an operator supervising all the operations. For this specific case, due to the small field size, the seeds refill was not counted in the analysis of the accessory time.

The results were then analysed and compared using statistical analysis.

Results

The results showed a big difference in the machine operating efficiency, 83% for the traditional tractor and 68% for the autonomous one, this is due to the different operating speeds, working width and the higher time required by the robot to perform the turns, on average 51 seconds compared to 14 seconds of the tractor. Considering the effective working capacity for this operation, the tractor worked at 2.1 ha/h compared to the 1.05 ha/h of the robot, and for the operational working capacity, 1.75 ha/h for the tractor and 0.71 for the robot. These findings will be more clearly explained in the final version of the paper.

Potentiality of Multispectral Vegetation Indexes for Evaluating the Influence of the Sowing Technique on Durum Wheat Cultivation Density

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Keywords: Precision agriculture, image processing, UAV, agriculture 4.0, digitalization

Objectives

Crop monitoring is one of the main fields of application of drone surveys in the agricultural sector. Multispectral sensors on board drones, allow acquiring detailed images useful for inferring crop vigorousness and health status thanks to the computation of spectral indices. Thus, areas of the farm or field with developmental problems (e.g. biotic/abiotic stresses) can be immediately recognized. For these reasons, the multispectral information gathered by drone during agricultural surveys is used to make thoughtful decisions and is part of the precision agriculture strategy. The purpose of the study is to monitor the greenness of a durum wheat cultivation over a period of time between the stem elongation and the inflorescence emergence stages, by comparing different sowing techniques: conventional (CS) and sod-seeding (SS).

Methods

The flight campaigns were conducted with a multispectral sensor (MicaSense RedEdge; MicaSense Inc., Seattle, WA, USA) on board a DJI quadcopter drone over an experimental field located in the territory of Aidone in the province of Enna, Sicily (Italy) (14.6060 E, 37.4410 N). The field measures about 1.4 ha and consists of plots on flat land and plots on sloping land. Two vegetation indexes were calculated using ArcGIS©: Normalized Difference Vegetation Index (NDVI) and Normalized Difference Red Edge Index (NDRE). An Analysis of Variance was performed for each flight campaign in order to evaluate potential differences in NDVI and NDRE among the sowing techniques.

Results

The results are still being processed, however, it can be said that no significant differences among seeding techniques were found in terms of NDVI; whereas NDRE for CS resulted significantly higher than for SS. In addition, both sowing techniques showed similar SD values, indicating that both methods performed equally in terms of durum wheat cultivation. These results could enhance the limitations of NDVI for detecting vegetation development patterns at high NDVI values (i.e. saturation); whereas highlight the potentialities of NDRE for identifying such differences.

Olive tree canopy assessment by UAV multispectral images before and after pruning

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Keywords: Smart farming, object-based image analysis (OBIA), vegetation indices

Objectives

Precision olive growing applications have been increasing in recent years to manage spatial variability and achieve high quality and quantity yields. Pruning is one of the most important agronomic operations to affect plant vigour conditions. This study aims to provide a new approach for estimating the impacts of the pruning biomass in the vigour conditions, using multispectral images acquired by Unmanned Aerial Vehicle (UAV).

Methods

The study was conducted in 2022 winter season, in an olive orchard located in western Sicily (Segesta, Italy). Multispectral images were acquired using an UAV Phantom 4 (DJI, China); in automatic flight configurations. Two flights were performed before (Day of Year 339) and after the pruning (DOY 364). Flights were set with an altitude at 70 m a.g.l. generating a ground surface distance (GSD) of 3.6cm/pixel. Side overlap and the forward overlap were at 70%, flight paths were generated by software to minimize the time of flight, gimbal pitch was set at 90° (Downwards). Starting from the Digital Elevation Model (DEM) and orthomosaic were applied the Object-Based Image Analysis (OBIA). OBIA were used to perform the canopy pixels segmentation from the soil and extract geometric and spectral canopy conditions. Pruning weight was measured in selected plants at the same time of the second flight. Correlation coefficients between geometric (canopy volume and area), vegetation indices (VIs) and pruning weight were calculated.

Results

VIs showed high correlation with canopy volume and area providing good prediction. This rapid and accurate OBIA methodology demonstrated high accuracy in olive canopy reconstructions and detection in changes of vigour conditions. The trial provides interesting potential to support olive growers to improve smart pruning management.

Sentinel2 Satellite Images to Discriminate Organic Cereal Crops Insouthern Italy

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Keywords: Remote sensing, satellite images, organic cereal crops, normalized difference vegetation index, chlorophyll content index

Abstract

Free medium resolution satellite images, as Landsat-8 and Sentinel-2, are ideal for offering a "low cost" product with wide automation possibilities and which allows high definition temporal control of the entire national territory. The present work aims to evaluate the possibility of discriminating organic cereal crops from those under conventional management by analyzing multitemporal satellite images. The Sentinel-2 images were chosen on the basis of their spatial (10/20 m) and temporal (5 days) resolution, which is optimal for this analysis. Sentinel2 images were used to create a map of the cereal fields and to calculate a biomass index (NDVI) and chlorophyll content index (MTCI) needed to monitor the crop throughout the phenological cycle. The study area was the entire Basilicata region, the study year 2017, the year in which a ground-truth-gathering was carried out. The results obtained from this study were very encouraging because they were able to provide indications on the areas declared for organic cereal crops which presented a crop development very similar to that of conventionally managed fields.

Pruning Weight Estimation Using Multispectral Sensors in a Vineyard in Southern Italy

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Keywords: Remote sensing, UAV, vegetation indices

Objectives

Precision viticulture demands characterization of the spatial variability of vineyard vegetative status to plan appropriate management. Pruning weight is an important indicator of vegetative growth and vine vigour. This study aims to provide a new approach for pruning weight estimation using multispectral sensors.

Methods

The study was conducted in 2021 growing season, in a traditional Mediterranean vine-growing area in western Sicily (Camporeale, Italy). The methodology is based on analyzing multispectral images acquired using an Unmanned Aerial Vehicle (UAV) in a vineyard of Catarratto cultivar. Data acquired by multispectral surveys were got during the summer period. Pruning weight was measured in appropriate sampling points during the winter season. Using NRG (Near Infrared-Red-Green) imagery two vegetation indices were calculated, precisely Normalised Difference Vegetation Index (NDVI) and Green Normalized Difference Vegetation Index (GNDVI). Object-Based Image Analysis Approach (OBIA) was used with the purpose of canopy pixels segmentation from the soil and shadows. Correlation coefficients between vegetation indices and pruning weight were calculated. Pruning weight was estimated with a linear analysis model.

Results

NDVI showed high correlation with pruning weight providing good prediction results. This rapid and accurate methodology demonstrated high accuracy in vineyard pruning weight estimation, providing interesting potential to support grape growers to improve vineyard pruning management.

ORAL PRESENTATIONS

TOPIC 8. Noise, Vibration, Dust, Endotoxin, Microorganism

Frequency Analysis From Electric Portable Harvesters for Olives

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Keywords: Safety, olive harvesting, vibration exposure, hand-arm system, thirdoctave analysis

Objectives

Exposure to vibration to the hand-arm system represents the most important risk connected with the use of portable harvesters for olive and other drupe harvesting. Their large use is aimed at reducing production costs with respect to the manual harvesting, when farm conditions prevent mechanical harvesting. Unfortunately, ergonomics and safety aspects are often underestimated by users, mainly interested in productivity. The main objective of this research is to evaluate the vibration transmitted at the Hand-Arm-System (HAV) at each third octave band frequency for each reference axis. The results may help manufacturers in design the machines so to reduce the vibration risk connected to their use.

Methods

Two models of portable harvesters were considered: a classical flap-type model (H1) and a model with an intrinsic partial compensation of the oscillations of the harvester head (H2). The harvester head H1 was applied to a fixed length rod and the H2 model to a telescopic rod. Both models were tested under idling and load conditions (during olive harvesting). Accelerations were measured in two points on the rod, near to the hand positions. All measurements were replicated three times and each measurement lasted about 90 s.

Acceleration was measured using three monoaxial accelerometers, arranged as a triaxial one, with reference axes fixed according to the UNI EN ISO 5349:2004 standard. Acceleration signals were sampled at the frequency of 5000 Hz and then recorded on the hard-disk of a PC by means of a four-channel PC-based acquisition unit. Subsequently, the recorded acceleration signals were post-processed in the laboratory by applying the one-third octave analysis in the frequency range 6.3-1250 Hz for each axis. Acceleration values were frequency weighted for each one-third octave band according to the UNI EN ISO 5349-1:2004 standard and the results were compared for each reference axis and each working conditions.

Results

Acceleration signal analysis is still in progress. Expected results will allow comparing working conditions and evaluating the vibration transmitted to the hand-arm system at each frequency. In addition, they may help manufacturers in design the machines and providing users with useful guidelines on safety aspects when using these machines.

Inhalable Wood Dust Produced During Chainsaw Operations

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Keywords: Wood particles, health risk, heavy metals, cutting practices

Objectives

Inhalable wood dust produced during chainsaw operations can pose a significant risk to the health of workers. Practices such as tree felling, pruning and chipping wood can produce significant amount of wood particles that can be inhaled by agricultural and forestry workers. The aim of the work was to evaluate the risk posed by wood dust during chainsaw operations.

Methods

The wood dust total suspended particles (TSP), and the respirable fraction (PM₄) were sampled by active filtering with personal air samplers. At the same time, to characterize the particle size distribution, samplings were also performed with a dust particle counter placed in the area surrounding the test's site. Wood logs of three different species (*Eucalyptus* sp., *Pinus radiata* and *Quercus cerris*) were employed for the cutting tests carried out in two separate trials (July and December). Some filter samples were undergone to chemical analysis to determine the contents of metals. Two chainsaws, one electric powered by batteries and one endothermic, were employed in the tests.

Results

Results showed that the different woods and the two chainsaws produced similar quantities of wood dust, that was characterized by a major fraction of fine particles < 1 µm. Obtained values of inhalable wood dust were very variable in values (in July's test, PM₄ ranged from 2.9 to 52.5 mg m⁻³ and TSP from 3.7 to 42.6 mg m⁻³; in December PM₄ ranged from 1.0 to 4.0 mg m⁻³ and TSP from 3.2 to 5.8 mg m⁻³). Values often exceeded the European legal threshold of concentration, and the operator should protect himself wearing a proper PPE (personal protective equipment). Moreover, attention should be paid to the exposure to wood dust and to heavy metal elements considering potential risks due to longer times of exposure that should be carefully evaluated.

Whole Body Vibration Exposure in Olive Harvesting by Means of Tractor-Mounted Harvesters: a Case Study

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Keywords: Vibration, tractor, olive harvester, exposure, health

Objectives

The aim of this paper is to evaluate the effect of Whole-Body-Vibrations (WBV) in tractor-driving farmers during the activities of olive harvesting by means of tractor-mounted harvesters. More specifically the focus of the work consists in highlighting the influence of the different work phases on WBV's exposure.

Methods

In order to obtain information regarding exposure levels, an experimental campaign was realized in a farm. A vibration dose was calculated by assigning each vehicle driven a vibration magnitude, estimated on the base of vibration measurement. The measurement was performed with two male tractor drivers, on different workstations and with different positions of the machine's shaking arm. The first workstation is that of the tractor driver, while the second one is located in correspondence of the seat supplied with the machine for the workers assigned to move the mechanical arm so as to shake tree branches. In order to characterize the phenomenon, the measurements were carried out with different inclinations and lengths of the shaking arm.

Results

The root mean square accelerations (r.m.s.) were calculated for the vibrations measured in both seats and under different conditions. The results highlight the different levels of exposure of the two operators during the activities. Furthermore, the data show that the mechanized movement of the arm greatly influences accelerations because it generates high stresses especially in the maximum extension with respect to the source signal produced by the tractor engine.

Application of ANN for the Identification of Discriminating Variables by Noise Analysis on Portable Motorised Equipment

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Keywords: Artificial intelligence, PPE, agriculture, mechanisation, noise

Objectives

Noise exposure is one of the main causes of occupational illnesses in agriculture. Typical machines exposing operators to this risk are motorised portable equipment. This work aims at analysing noise data emitted by this kind of machines and identifying key discriminatory variables, through an artificial neural network (ANN). This study allows a 'diversified' noise risk analysis for each type of machine, enabling the use of the most appropriate personal protective devices according to the different types of equipment.

Methods

Using a class 1 Larson Davis 824 integrating sound level meter the noise emissions of 153 motorised portable equipment were analysed. Measurements involved more than 30 farms. The types of equipment used in different work operations were 55 brushcutters, 52 chainsaws, 17 hedge trimmer, 23 blowers and 6 olive harvesters.

A classification model based on artificial neural networks (ANN) was implemented. This made it possible to investigate discriminating variables on noise emitted by different types of equipment.

Results

Results show that chainsaws have a higher average equivalent value of noise, with a L_{eqA,T_e} of 99.9 dB. This is also confirmed by the octave bands analysis, showing that the dB value emitted by chainsaws is far higher than other equipment in all bands but 63 Hz.

The analysis performed allows the identification of different operating machines through the emitted noise. Moreover, thanks to an accurate variable impact analysis it is possible to address their specific impact on the operator's health.

Indeed, by evaluating the noise emission of each type of equipment at different frequencies, it is possible to identify those responsible for the highest risks.

Such investigations could provide the opportunity for the appropriate selection of personal hearing protection equipment, without the need for specific in-field measurements.

Numerical identification of operative limits for farm tractors by considering vibrations along the drivers' rachis

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Keywords: Agricultural work, exposure to vibrations, whole-body vibrations, response surface modelling (RSM), operative limits of farm tractors

Objectives

The muscular fatigue of a worker, even before being a pathological condition indicative of an excessive biomechanical overload, is itself responsible for possible increase of accidents in the very short term. Indeed, it leads to an impairment of usual movements that the worker performs to carry out familiar tasks, and also to the execution of some movements in a different way, to preserve the residual energy. Exposure to vibrations is a known and common source of worker fatigue, especially for agricultural machinery operators. The aim of this study is finding a way to quickly and easily detect any altered status of a worker, even before any personal perceptions, to impose some intervals capable to limit the accumulated fatigue and, thus, prevent possible accidents at work.

Methods

The quantification of fatigue status is not a simple matter, as it is multifactorial (it also depends on the individual's physical performance/training and environmental conditions) and its perception is extremely subjective. While the best objective index might be the concentration of lactic acid within the muscles, this is not a viable option in a work-related context, as it is not quickly carried out and because it requires laboratory instrumentation. Hence, an indirect correlation of the fatigue status due to a prolonged exposure to vibrations was considered, e.g. by measuring some physiological parameters, e.g.: heart rate, min/max blood pressure, blood oxygen saturation level, body temperature, electrolytic conductivity of sweat. These medical parameters can be investigated by means of wearable devices and in a rapid manner and, above all, they can be used as objective discriminating factor for a worker's condition, especially if compared to a normal condition of the same subject.

Results

Some tests were carried out, recording physiological parameters over time and also asking the identified subjects about their perception in terms of muscle fatigue. No parameter resulted to be statistically indicative of the fatigue status by vibrations, due to a delay of about 2 hours in the release, by the central nervous system, of cortisol (able to alter many the physiological parameters, e.g. the ones controlled in the performed tests). Unfortunately, after this time, the condition of fatigue begins to be clearly perceived also by the subjects and the recovery times are already compromised.

Quantifying Farmers' Exposure to Grain Dust and Occupational Noise

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Keywords: Respirators, decibel level, on-farm grain bins

Objectives

The project addresses the U.S. National Occupational Research Agenda (NORA) report for Agriculture and the National Institute for Occupational Safety and Health (NIOSH) Research to Practice (r2p) goals to enhance the knowledge, interventions, and recommendations for Ohio grain operators. The study assessed farmers' exposure to grain dust and occupational noise present at on-farm grain storage / handling facilities.

The two research objectives included: 1) Quantify grain farmers' personal exposure levels to grain dust and occupational noise. 2) Evaluate the protection factor of commonly used respirators farmers used while working at their on-farm grain bins.

Methods

Ohio farms with on-farm corn and soybean storage bins were recruited winter 2022 and spring 2023. Prior to an on-farm visit participants completed a survey to understand their knowledge of, and behaviors to use, respirators and hearing protection.

During the on-farm sampling phase, farmers wore their own respirator and a backpack equipped with personal sampling equipment while they performed bin cleaning work. Two TSI DustTrak DRX Aerosol Monitors 8534 recorded real-time size segregated dust concentration data, such as TSP, PM10, RESP, PM2.5 and PM1. One DustTrak measured the dust concentration outside the farmers' PPE, while a second measured inside their respirator. A respirator protection factor was calculated. A TSI Quest EDGE5 noise dosimeter measured farmers' personal noise exposures for the continuous sound pressure level (SPL), maximum (Max) SPL, minimum (Min) SPL, peak SPL, OSHA percent dose, OSHA 8-hr TWA, ACGIH percent dose, and ACGIH 8-hr TWA.

Results

Data collection efforts are in progress. Early results indicate respirable dust concentrations exceed the working range of NIOSH recommended levels. Likewise, occupational noise is consistently measured at 85+ Decibels.

Objective 1: Identified conditions (i.e. temp, humidity, and other workplace practices and grain bin equipment) that impact air-suspended dust and noise levels over 85dB. Objective 2: Quantified true protection factors of farmers' PPE during typical work. Overall, our results will impact the safety culture for agricultural workers.

ORAL PRESENTATIONS

TOPIC 9. Occupational Health

International Perspectives on Farmers' Psychosocial Working Conditions and Mental Health

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An international systematic review was made by request of the Swedish Agency for Work Environment Expertise (<https://sawee.se/>) to provide an overview of research relevant to farmers' psychosocial work environment and mental health. It contains knowledge about the farmer's challenges and consequences in the form of stress and risk of mental illness, opportunities to deal with these challenges yourself or through various forms of support. Important aspects also include the profession's health factors and its development opportunities that contribute to a good working environment.

A systematic international literature search was carried out with a focus on studies about farmers, and thus excluded employees and entrepreneurs who had a focus on forestry. Furthermore, the search was limited to the period 2005–2021 and to countries that have similar production forms and production conditions as in Sweden, mainly Europe, North America and Australia/New Zealand. The literature search resulted in 108 scientific articles based on qualitative and quantitative studies, of which only a few came from Sweden.

Being a farmer is more of a lifestyle than a profession. The freedom that come with the profession is more important to many farmers than a high income. Farmers also have a strong relationship with the place where they live and work, which is important to them and a central part of their identity. The farm symbolizes their values and personality as they usually built everything themselves. The absolute majority of farms are family farms, where you live and work together with your partner and children, sometimes with parents or parents-in-law. Many farms have been owned by the family for several generations and the farmer lives with the changes of the seasons close to animals and nature more than is usual in other professions and forms of business.

The results showed that the work environment risks identified in farmers' psychosocial work environment are; workload, economy, climate change and weather conditions, crime, globalization, laws and regulations, masculine norms and loneliness, isolation and lack of support.

Mental ill health is generally higher among farmers, especially among older farmers, than in other occupational groups. Farmers have a higher incidence of depression and suicide attempts than other professional groups, and farmers' mental illness has increased in recent years.

Health factors in the psychosocial work environment of farmers are not as well studied as risk factors. The health factors identified are; the link between the farmer and the cultivated land, environmental and social responsibility, the ability to do work, to be outside, to work physically, to eat well, good working and living environment, to work with animals, reasonable workload, own motivation, social support and sense of belonging, an income that did not come from working on the farm and the ability to work after retirement age.

The farmers' ability to withstand and recover from the stress they face in their professional role (resilience) varied between individuals. Support from family, nature and animals and setting limits to their work commitment, relaxing, or doing other things (than work) also contributed to strengthening their resilience. Resilience is something that can be learned which can be helpful for farmers. Farmers use different personal strategies to manage the stress they are exposed to (coping), and different coping strategies can also contribute to building farmers' resilience. It can be planning, positive reappraisal (change in attitude to stressful events, humor, and leisure) and getting help and support from others. Furthermore, acceptance can be used as a coping strategy. More negative strategies can

be avoidance, as well as blaming oneself or others. It can also involve suppressing emotions, avoiding problems, or consuming alcohol.

According to several studies, the fact that farmers seem to be less likely to seek out and use resources and services for mental illness is due to a lack of regional resources and professional-specific knowledge about the target group. Farmers had the greatest confidence in, and were therefore most receptive to, information about mental health from doctors, but also from their spouses/family members and friends. The agricultural movement can contribute to social support, education, and mentoring programs for farmers with stress and depression symptoms. Future suicide prevention efforts for farmers can also take place through education, training programs and national campaigns. In the review of the literature, it has also been established that there is a need for more knowledge regarding; female farmers' working conditions and mental health, the consequences of changes in the countryside through deteriorating community services and increased crime. Studies and evaluations of various forms of support and interventions to support farmers' mental health are needed on a larger scale. An EU report on the future working environment in agriculture also points to the importance of increased knowledge about the stress factors expected to be linked to climate change, economic and financial stress, increased demands from authorities and consumers, negative criticism of agriculture including militant activists. From a Swedish perspective, there is a strong need for in-depth knowledge about how the psychosocial work environment and the mental health touched on in this systematic review apply to Swedish farmers in the 2020s, even if the international results contribute to increased knowledge that is largely transferable to Swedish relationships.

Download full report: https://media.sawee.se/2023/03/Farmers_psychosocial_work-environment_and_mental_health_digital.pdf

Immersive Process Ergonomics by Wearable Devices: From Automotive Experience to the Applicability of Technology in All Manufacturing Sectors

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Keywords: Virtual simulations, human-centered, ergonomics, assessment, training

Objectives

The work presented is about the development of an integrated tool for ergonomics riskassessment index calculation, using motion capture in 3D environments.

Methods

Industry 4.0 passes through the concept of smart factories, bringing into the industrial context a new vision of production lines and workflows, which can now be designed considering ergonomics and thus the interaction among operators, machines, and tools, in accordance with human-centered design principles.

Virtual simulations help in reproducing such interactions and in foreseeing solutions to improve the working conditions before installing tools and equipment. In addition, motion capture techniques have proven capable to guarantee the reproduction of humanmotion with sufficient accuracy.

Results

Starting from motion capture acquisitions, an engine for postural angle calculation, in accordance with international standards, and a Unity-based application have been specifically designed and validated. The technology can be adopted also in agriculturefield for design, assessment and training purposes.

Assessing the Physical Mismatch Between All-Terrain Vehicle Controls and Youth Strength: Implications for Agricultural Safety

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Keywords: ATV, farms and ranches, physical capabilities, youth injury prevention, quadbike

Objectives

This study aims to assess the potential discrepancies between the required activation forces of the controls of 54 utility ATVs and the strength of male and female youth of varying ages (6-20 years old) and strength percentiles (5th, 50th, and 95th). In addition, we also assessed if youth strength is enough to push the ATV off if they are pinned underneath it, which is a common post-rollover scenario that can result in death by mechanical asphyxia.

Methods

To achieve this, the activation forces of the ATVs' controls were measured experimentally, while the corresponding strength of the youth was obtained from literature sources. A handheld force gauge, a button load cell, and a pressure glove were used to measure the activation forces of the main controls (handbrake, footbrake, handlebar, throttle lever, ignition switch, headlight switch, hand gearshift, and foot gearshift) of the utility ATVs.

Results

The findings of this study reveal a physical mismatch between the forces needed to operate the ATV controls and the strength of the youth, thereby compromising their ability to ride ATVs safely. The most challenging ATV operation tasks for the youth were pressing the footbrake and pushing the ATV off (if pinned underneath it). For instance, youth aged 6-10 would be able to activate the footbrake of only 64% of the evaluated ATVs. The inability to depress the footbrake affects the youth's ability to reduce the speed or stop the ATV and can prevent the operator from diverting from obstacles or potential bystanders. The results were even more striking when considering the ability of a youth operator to push the ATV off if pinned underneath it. Less than 13% of all evaluated vehicles could be pushed off by male operators aged 16-20 years old of the 95th strength percentile, the strongest subjects of this study. The observed discrepancies between ATV controls and youth strength put young riders at an increased risk of crashes.

Evaluating Youth's Physical Capabilities to Ride Utility All-Terrain Vehicles: Anthropometric Reach and Field of Vision

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Keywords: ATV, farms and ranches, youth injury prevention, quadbike, virtual simulations

Objectives

The objective of this study was to evaluate youth's physical capabilities to ride utility ATVs in two areas: anthropometric reach and field of vision.

Methods

The assessment was carried out through virtual simulations in an ergometric software (SAMMIE CAD). We evaluated male-and-female youth of nine different ages (8 – 16 years old) and three height percentiles (5th, 50th, and 95th). The anthropometric reach simulations included seventeen utility ATVs and eleven reach-based ATV fit guidelines proposed by several ATV safety advocacy organizations. Conversely, the field of vision simulations included three-dimensional mockups of ten utility ATVs, humans, sprayer tanks, windshields, and simulated obstacles.

Results

The results demonstrated a physical mismatch between ATVs' operational requirements and youth's anthropometry. For instance, male-youth aged 16 years old of the 95th height percentile failed to pass at least one out of the eleven fit guidelines for 35% of all vehicles evaluated. The results were even more concerning for female operators, where female youth 10 years old and younger from all height percentiles failed to pass at least one fit guideline for all (100%) ATVs evaluated. Furthermore, our simulations indicated that youth ATV operators typically have a diminished field of vision compared to adults. Particularly, youth aged 6-11 years old (male and female) have the most limited visual field. Limitations in the field of vision compromise the riders' ability to see the ATV's controls, which could cause them to lose the vehicle's control. In addition, a limited field of vision negatively affects the riders' capability to perceive the riding environment. These limitations clearly compromise the youth's ability to ride ATVs, increasing their risk of crashes. In conclusion, the physical capabilities assessment demonstrated significant concerns for youth's ability to ride utility ATVs, particularly in relation to anthropometric reach and field of vision. These findings highlight the need for implementing effective ATV safety education and regulation.

Safeguarding Youth from Agricultural Injury and Illness: International Perspectives

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Keywords: Agriculture, youth, children, injury, illness

Objectives

Advocates for the safety of children who work and/or live in agricultural settings are eager to strengthen international collaborations that will facilitate sharing of resources and research findings. The result could help us to efficiently reduce the toll of preventable agriculture-related injuries and illness affecting children (0 to 18 years). Objectives of this endeavor were to: 1) reach out to international communities to identify any organized efforts focused on childhood agricultural safety; 2) encourage individuals or groups to assess and document the status of efforts in their respective countries; 3) publish relevant commentaries, interventions and research methods via a dedicated online journal; 4) synthesize findings such as areas of success and complex or unresolved issues; and 5) propose strategies for future international collaborations including technical assistance and shared resources.

Methods

A seven-member editorial board represented USA, Sweden and Australia. Decisions were made regarding priority themes (e.g. evidence-based strategies, public policy, intervention targeting the most hazardous work) and categories of papers (e.g. commentary regarding a country's child agricultural injury data and prevention activities, original research, brief report). A list of contacts in 31 different countries was generated to solicit potential authors. In March 2022 a "call for papers and commentaries" to be published in the online *Frontiers in Public Health* was widely disseminated. Potential authors submitted abstracts for consideration. The editorial team provided guidance and some financial assistance to authors if requested. The chief editor interacted with the journal staff to ensure papers moved through the system with appropriate peer reviews, revisions, and resubmissions.

Results

Within five months of the Call for Papers, 30 manuscripts were submitted through the online portal. As of April 2023, there are 29 papers representing 11 countries that are published in a dedicated issue of *Frontiers in Public Health* <https://www.frontiersin.org/research-topics/31701/safeguarding-youth-from-agricultural-injury-and-illness-international-experiences>. Commentaries regarding a country's situation are from Argentina, Australia, Burkina Faso, Canada, Ireland, Sweden, United Kingdom, and United States of America (U.S.). The collection also includes 16 research studies from authors in Australia, Israel, Lithuania, Nigeria, and the U.S. (including the territory of Puerto Rico) and well as program descriptions. A primary result stemmed from the difficulty in reaching potential authors from the pool of contacts. Indeed, it was troubling to hear that the topic of youth and safety in agriculture is not being formally addressed in many countries while it is well-known that, world-wide, agriculture is one of the most dangerous forms of work, and is associated with debilitating trauma and chronic diseases. Some areas of success were noted in countries where safety programs targeted toward family farmers have been

ongoing for many decades. The most common challenges reported were the lack of disease and injury surveillance data and the failure of public policy and regulations to be enforced.

Authors who participated in this dedicated journal issue will have an opportunity to share the E-book of publications on this important topic to raise the profile of this topic within their own geographic region and beyond. Ultimately, we hope that international collaborations can speed up the sharing of successful safety strategies and foster changes that minimize adverse exposures of youth working and living in agricultural settings.

Safety and Ergonomics on Forestry Sites. A Sector Overview and Bibliometric Analysis

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Keywords: Forestry-operation, machines, work-safety, work-risk

Abstract

The subject of occupational health has long been of great importance in various employment sectors. The great attention shown by the scientific community towards this issue has led to a large production of laws, standards and other tools (such as user and maintenance manuals, data sheets, etc.) aimed at safeguarding safety in the workplace. However, the forestry sector, characterised by high-risk operations, has lagged behind more established realities. The aim of this work is to propose an overview of scientific production on the topics of health and safety in forestry sites and a bibliometric analysis aimed at defining the state of scientific production in the sector, the most influential contributions and authors, and lines of research development.

Analysis of the Formation and Safety of Non-Specialised Operators Working on Public Urban Green Sites

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Keywords: Urban-green, social-inclusion, work-safety, work-risk

Abstract

Often those working in the urban green maintenance sector are not specialised and trained operators, but volunteers, trainees or casual workers. In this paper, we have carried out a detailed analysis concerning a particular situation, namely that of traineeships carried out in the context of urban green maintenance operations aimed at people who have a particular vulnerability and fragility, also in terms of distance from the labour market, and who are in the care of social and/or health services. Actually, this situation is becoming very widespread in Italy, also in relation to the social inclusion policies implemented in recent years. A clear picture is therefore needed on aspects such as training, risk perception, knowledge of the activities and tools used in these operations.

Lights and Shadows of Agricultural Workplace Safety Legislation in the Main EU States

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Keywords: Safety, work, law, European union, agriculture

Objectives

The world of occupational safety has attracted more and more attention from the European institutions. In fact, it is represented that in 2020 in Europe there were 2,735,566 total accidents in the workplace, of which 108,508 occurred in the agroforestry sector.

The objective of this work is to carry out a comparative analysis of the legislation on health and safety in the workplace in the European countries that have recorded a high number of accidents in the last three years, namely: Italy, Germany, Spain and France.

Methods

The data acquisition was carried out through the study of the Eurostat and EU-OSHA databases and, subsequently, the legal provisions on health and safety in the workplace of the aforementioned countries were analyzed from a comparative perspective. The main competent authorities for the prevention of occupational risks for the promotion and improvement of working conditions were also analysed. Lastly, particular attention was paid to the type of legislative act chosen to regulate the matter of safety in the workplace.

Results

It has been analysed that Italy and Spain have not included the right to health and safety in the workplace in their Constitutions but have transposed the European directives through legislative acts of primary rank (Legislative Decree 81/2008 - TUSL and law n. 31 /1995 - LPRL) leaving only the general protection of health to its Constitutions (art. 32 in Italy and 43 in Spain). France has regulated the matter with the Loi 93-1418 of 31 December 1993 with a strong pro-European connotation, bringing together the legislation in a single act. In all three States, these are simple and linear management systems, where the main competences are in the hands of the government.

Germany has the most complete and articulated legal framework, despite being the first nation for number of accidents per year. The German system is characterized by its dual structure as it includes the state occupational safety and health organizations and the autonomous accident insurance organizations. The state administration promulgates laws, regulations and orders issued by state commissions; the accident insurance institutions issue their own accident prevention rules after examining their own needs and with the approval of the federal government and the individual federal states.

Work-related Injuries and Illnesses Among Restaurant Workers: A Review

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Keywords: Safety, health, workplaces, musculoskeletal disorders, catering

Objectives

The restaurant sector until a few years ago was not considered one of the most dangerous in terms of occupational safety, so much so that it is classified as a low-risk economic activity. The cases of accidents and so-called "white deaths" in recent years have led to greater attention being paid to the regulation of this category on safety risks in workplaces of catering sector.

Professional cooks are the category most at risk and the most frequent causes of accidents are slipping, sudden movements and loss of control of utensils and sharp objects. The most frequently reported occupational diseases concern the musculoskeletal system and connective tissue, followed by those of the nervous system. The aim of the paper is to present a review on the work-related injuries and illnesses among restaurant workers by analysing the results conducted by other authors in the last years.

Methods

The methodology involved different and subsequent steps. A first phase concerned the definition of the field of investigation; the next phase included the selection of research papers on databases and the study of results of the research conducted on the subject by other authors; the last phase organised the data through the tables and graphs preparation.

Results

The findings from this study can support efforts by the restaurant industry, safety and health services and offices to observe the influence and effects of work safety culture within restaurants. Prevention measures combining activities on personal and occupational risk factors would be effective by implementing actions of promotion of health at restaurant workplaces in addition of actions on occupational risks.

Ergonomic Evaluation in the Use of Manual Agricultural Tools: New Analysis Methodologies

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Keywords: Ergonomic evaluation, agricultural tools

Objectives

In Italy, the agricultural sector employs around 1 million workers. As is known, during these activities, manual agricultural tools are used, which require a considerable ergonomic and muscular commitment of these workers, with the risk of the onset of musculoskeletal diseases. The aim of the study was to evaluate the ergonomic impact on the musculoskeletal system of manually operated agricultural equipment, through the use of new analysis methodologies.

Methods

The study was conducted on 10 healthy male volunteers. The agricultural equipment used for the study were: a rotary cultivator (Pubert-55P-C3) and an electric olive harvester (Campagnola-Elektra-185-270cm). Before carrying out the test, the symmetry of the spine was evaluated using the Spine 3D system (SensorMedica, Rome, Italy). (3). Muscle activity was evaluated by surface electromyography (OT-Bioelectronics). The evaluation of muscle activity was investigated before test t0 and after test t1 by the use of infrared thermography (IRT), dynamometer (BioFet) and myotonometer (Myoton- AS). In addition, working posture, i.e. trunk inclination (TI) and leg-hip-shoulder complex (LHS), were analysed.

Results

10 healthy volunteers were analysed. From the analysis of the preliminary data, following the use of the rotary cultivator, a significant variation in the temperature of both the dorsal and lumbar tracts and a significant depletion of muscle strength in the biceps and triceps brachii was observed (t0 vs. t1). Also with regard to the measurements conducted after the use of the harvester, a significant variation in the temperature of both the dorsal and lumbar tracts and a significant exhaustion of the muscle strength of the biceps and triceps brachii were observed (t0 vs. t1).

European and International Policy Impacts on Agri-Food Occupational Safety and Health Systems - Past, Present and Future

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Keywords: Farm safety and health, european union, CAP and social conditionality, ILO/FAO

Objectives

Building on the 2021 EU-OSHA farm safety report, two key authors of that report (Jones and McNamara) will place into context the actual situation regarding EU, International and (a number of) national policies in terms of farm safety and health. They will evaluate their impacts on the present agri-food occupational safety and health systems and identify future options for EU and International policy mechanisms and EU funds to improve national agri-food occupational safety and health systems.

Methods

In the absence of a specific EU OSH Directive for the agriculture sector, the authors will describe a sample number of national systems in OSH farm safety. They will then identify how EU and International policies and funding mechanisms related to the OSH and agriculture sectors could influence national farm safety and health and social sustainability systems in the future. The authors will be supported by a number of national policy forums under the EU SAFEHABITUS project (commissioned by the ECDG AGRI) and by the European Policy Forum (EPF) which is the major policy tool of the SAFEHABITUS project.

Results

These preliminary results will provide some first policy reflections related to the SAFEHABITUS European Policy Forum (EPF) which is the major policy tool of the EU SAFEHABITUS project. The EPF will identify key policy issues and funding mechanisms in EU farm safety and health policy area and is expected to influence agricultural safety and health policy over the coming years.

A Survey for the Introduction of New Parameters for the Assessment of Work-Related Stress in Agriculture

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Keywords: Occupational safety, agricultural sector, injury, online survey

Objectives

The Legislative Decree 81/2008 and its subsequent amendments, require the assessment of stress-inducing factors for workers. Such condition places employees in potentially dangerous situations, as they may be subject to injury. The numerous elements enabling the assessment of the aforementioned risk are, however, relevant to all work sectors, hence non-specific. The aim of this work is to devise, by means of a survey, new assessment parameters to be introduced into the national survey and specifically for the agro-silvopastoral sector.

Methods

Data acquisition was carried through the administration, to a sample of over one hundred farms distributed across Italy, of an online form. In the survey, 28 questions were sampled, including new proposals and questions that had been revised for the agricultural sector. Here, the participants could indicate, if what was being proposed was a new stress factor found in their work environment; or if the proposed indicator was appropriate for the assessment of work-related stress in agriculture.

Results

Approximately 58% of the population surveyed fell into the "Employer" category and more than half had a completed secondary school education. Moreover, the results from companies located in the North of Italy were predominant.

The new parameters that were introduced, generated a high degree of interest in the sample which was evaluated: in fact, of all the questions, approximately half expressed a favourable opinion on the introduction of the proposed parameters.

Work Safety Issues in Non-professional Vegetables Gardens

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Keywords: Hobby farming, health and horticultural production, farming accidents, training with farm machinery

Objectives

The aim is to study the reality of non-professional vegetables gardens (NPVGs), thus acquiring a higher awareness about its dimension and relations with occupational safety.

Methods

More than a thousand questionnaires were proposed in Friuli-Venezia Giulia (in the North-East of Italy) to learn about the typical size and the possible use of machinery and equipment in NPVGs. This, together with a survey in local newspapers and hospital facilities has been used to derive the number of accidents, including the fatal ones, caused by activities performed during agricultural operations in NPVGs.

Results

NPVGs can be placed in an urban, peri-urban or agricultural context. Only 15% of them have a surface smaller than 50 m², are exclusively devoted to family self-consumption and managed by using only manual tools. Another 40% includes NPVGs with up to 1000 m², structured for vegetable production but also presenting fruit trees, livestock and wooded areas. NPVGs up to 1 ha are the 15% of the total, while the 30% of them are over 1 ha and have wooded areas. About 20 million people in Italy are employed in this agricultural reality, which has an economic and social value. The management of NPVGs makes use of a wide type of processes and machinery for the preservation of products (such as chainsaws, blowers/aspirators, engine-driven cultivators, robotic lawn mowers, etc.), and the sector of gardening machinery and equipment has seen considerable increases. As 54% of NPVGs have mechanical equipment, the problem of user safety in using machines emerges prominently, accentuated by the fact that this is an unregistered reality, there is no obligation for the training of users or the provision of PPE. A macroscopic fact emerges if looking at fatal accidents in agriculture: official INAIL data report an average of about 66 accidents per year in the five-year period 2017-2021, but ASAPS website (road safety portal) indicates more than 160 accidents/year due to the tractor in the same period. This means that there are many more accidents in the non-professional world than in the professional world, so a careful assessment needs to be made and action needs to be taken e.g. at the level of training and accident prevention

Taking Tractor Training to the Virtual Limits for Youth Safety

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Keywords: virtual reality, education, young workers

Objectives

Virtual Reality (VR) is a training method used in military operations, surgical procedures, industrial safety courses, and pedestrian safety trainings. Knowing the hazards associated with tractor and machinery operation, a team of educational researchers developed and tested a VR training program for use in high schools, colleges, and universities to provide students with knowledge and skills for operating dangerous equipment. This study evaluated a VR tractor operation experience as an alternative training tool before students operated a real machine. The objective of this research was to describe teachers' and students' User Experiences following a trial period. The population was 7th-12th grade school-based agricultural education students in Ohio. Students were recruited by their agricultural education teachers who were willing to teach with the VR equipment.

Methods

A total of 55 Ohio schools elected to participate in the study, and received an Oculus Quest/Quest 2 VR headset. The teachers taught their normal tractor safety curriculum, then gave students the VR experience to complement their training. Students completed a survey to measure their User Experience with constructs related to presence, engagement, immersion, flow, skill, usability, judgment, emotion, technology adoption, experience consequence. Constructs were measured on a 10-point Likert scale. Descriptive statistics described the User Experience model and its constructs. Teachers also described their User Experience after interaction with the VR program, and a sub-set were interviewed about the utility of VR in the high school classroom.

Results

Virtual Reality has potential to be an effective training method and creates a realistic simulation for young workers. Objective 1: students ($n=132$) rated ten constructs over a neutral score, with Experience Consequence and Technology Adoption rating the highest, and Flow and Usability constructs the lowest. Objective 2: teachers ($n=13$) rated every construct with a mean score over neutral, except for Flow; the highest constructs were Experience Consequence and Engagement, while Flow and Skill constructs were lowest. Interviews revealed teachers had a semi-realistic experience inside the headsets. They reported three barriers of VR adoption as: classroom /resource management, technology barriers, and negative emotions. Both groups expressed excitement about a new teaching method for a traditionally-taught topic.

A Wearable Tracking System to Evaluate SARS-Cov-2 Virus Transmission Risk During Pruning Operation

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Keywords: GNSS, safety, social distancing

Objectives

The aim of the study was to assess the tracking ability of properly designed devices to determine SARS-CoV-2 virus transmission risk; the devices were implemented with an external GNSS (Global Navigation Satellite System) antenna, in different agriculture working conditions.

Methods

Two wearable devices were developed at the Department of Agricultural, Food and Forest Sciences of the University of Palermo. The devices were made up of: a power supply system, a GNSS receiver, a Low Frequency Communication System (LFCS) and an Electronic Control Unit (ECU). The devices were able to register their GNSS position every thirty seconds. Therefore, when the LFCS detected a contact with a device, GNSS position and duration of the contact were stored. The contact distance between the devices was set under two meters, according to the health regulations established by the government to reduce SARS-CoV-2 transmission risk. The trials were carried out in two different Sicilian agronomic environmental and working conditions, during winter. The wearable devices were tested during pruning operations in tendon training vineyard system and olive intensive orchards. In both orchards, the pruning operations were carried out in the two phases of cutting and removal of woody shoots. For each individual operation, the number and duration of the contacts between the two operators were evaluated.

Results

The results showed that the devices were able to accurately track the position of the operators. In particular, the LFCS was useful for identifying the distance between the two devices, while the GNSS system was an accurate tool for georeferencing contacts, and the route taken by the operators.

AgriStress Helpline: 24/7 Crisis Line Built for Farmers and Ranchers

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Keywords: Mental, health, response, suicide, intervention

Objectives

The objective of the AgriStress Helpline is to prevent deaths by suicide among those working in agriculture in the US. Not only do the agriculture, fishing, forestry, and logging industries have some of the highest rates of fatalities and injuries across all age groups, but also some of the highest rates of suicide.

Methods

AgriSafe Network is a US based 501©3 non-profit that works to educate healthcare professionals and agriculture workers about the health and safety needs of those in the agriculture, fishing, and forestry industries. Our mission is to *protect the people who feed the world* – and in addition to education, we are cultivating a network of trained agricultural health and safety professionals that understand and support Total Farmer Health®.

AgriSafe recognized the gap in mental health services and collaborated with another non-profit (ViaLink) to design and launch the first suicide intervention crisis line for agricultural communities. The model was designed by credentialed professionals trained to respond appropriately to the agricultural community, through a program developed by experts in mental health, agriculture production, mediation, and financial analysis. The crisis line utilizes a “care navigation” process where the helpline responders: triage for safety and provide de-escalation using a crisis intervention model; provide emotional support and coping techniques; and, when necessary, direct callers to the appropriate resources for their situation.

Results

While there are a handful of agricultural resource and referral lines, the AgriStress Helpline is the only crisis support line in the US currently dedicated to agricultural, forestry, and fishing communities. Launched in February 2022, AgriStress Helpline call data demonstrates that the crisis line has met the needs of the callers to date (n=274). Metrics of the call response indicate the line is responsive with an average answer rate of approximately 18 seconds. In addition to both call and text capability, the 24/7 toll-free AgriStress Helpline has a translation capability of 160 languages.

Interest in expanding the line from six states to a national line is evident by the high number of farm associations advocating for one national line. In addition, states such as Oregon and Texas have passed legislation to ensure sustainability of the crisis line. The national crisis line concept is currently under consideration in the next Farm Bill.

The Pact for Skills and the blueprint projects FIELDS and I-RESTART: Actions at European level for improving the knowledge and skills in the agri-food sector

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Keywords: Skills, European strategy, agriculture, agri-food industry

Abstract

The Pact for Skills brings together various stakeholders to ensure high-quality vocational education and training, as well as upskilling and reskilling of the European workforce in all ecosystems, including the agri-food sector. This initiative aims to meet the challenges of green and digital transitions while attracting and retaining a skilled workforce. The agri-food ecosystem, comprising the largest producing and manufacturing sectors in Europe, faces globalization, climate change, changing consumer demands, and competition. The ecosystem requires a skilled workforce, including agronomists, sustainability experts, digital and food technologists, while addressing skill shortages, bridging curriculum gaps, and supporting SMEs. The Pact for Skills aims to develop partnerships, enhance vocational education, promote lifelong learning, and improve sectoral attractiveness. It plans to monitor progress, recognize skills, and align with sustainable development goals.

The roadmap will also utilize resources from projects like Food-STA, ASKFOOD, FIELDS, and I-RESTART, supported by the European Commission. Stakeholders such as farmers, cooperatives, processors, associations, EU confederations, and education organizations will be engaged through the social dialogue framework. Actions will be accompanied by Key Performance Indicators (KPIs) to assess impact and progress. Communication will be improved to attract young talent and address the challenges faced by the ecosystem. Special attention will be given to small and medium-sized enterprises (SMEs) to align their specific skills needs.

The Pact4skills is associated with both the FIELDS and I-RESTART projects, coordinated by the University of Turin and the Confederation of Farmers - Confagricoltura. Within the actions for the two large projects, there is the establishment of a strategy at European and Country level to empower the skills of present and future workers in the agrifood sector, through focus groups, interviews and surveys.

ORAL PRESENTATIONS

TOPIC 11. Precision farming and traceability

Precision Agriculture, Ergonomic Risks From the Use of Assisted Driving Systems

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Keywords: Precision agriculture, ergonomic risk, assisted driving, thermography

Objectives

In the field of precision agriculture, tractors cab can be equipped with a satellite system have a monitor whose position must also guarantee the operator's visibility towards the outside. However, the angle of the monitor can cause posture that may reduce operator comfort. The operator's posture, muscle effort and comfort were evaluated during semi- automatic driving of the tractors, with respect to the position of the monitor in the cab. In particular, the influence of the angle of the monitor with respect to the frontal vision of the driver was evaluated (30°, 50°, 80°).

Methods

The evaluation consisted of semi-automatic driving on a tractor equipped with a satellite antenna. The measurements were performed using: surface electromyography and thermal camera. Electromyographs were placed right and left on the arms and back. A pressure matrix using sensors equipped with load cells made it possible to acquire the barometric data relating to the pressure exerted by the operator's body on the seat.

Results

10 healthy volunteers were analysed. The muscle activation shown a significantly increasing of the values from a guide with a monitor at 30° up to 80°, with greater activation of the hemisome compared to the right one. Similarly, the pressure exerted by the operator on the seat was probably increasing going from driving with the monitor at 30° up to 80°. On the other hand, the position of the monitor at 30° seems to reduce the operator's frontal visibility towards the outside. While driving, the operator must pay close attention both to the outside of the cab and to the monitor where the virtual guidelines are drawn.

Experimental tests have evaluated how the monitor positioned at 80° can negatively affect posture and muscle fatigue and therefore operator comfort. Research needs further insights, the results of which can improve the preventive action on operator fatigue, suggesting constructive and design solutions.

Farmers' Perception of Smart Farming Technologies: Investigating Aspects to Enhance Agriculture Digitalization

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Keywords: Farmers' perception, innovation adoption, Italy, survey, innovative vehicles

Objectives

Smart Farming Technologies (SFTs) comprise a large set of technologies which can increase the sustainability of agricultural production and farmworkers' safety. SFTs can include drones, sensor for data acquisition, weather data from satellites, software and agricultural apps for technical and economical management, robots and autonomous machines and tractors equipped with electronic systems and sensors. However, despite the increasing use of innovation during farming activities, the demand and the widespread adoption of these digital technologies seem to be quite far. Based on this, the present study aims to contribute to current literature investigating whether there are significantly different barriers and drivers of adoption among different types of SFTs, comparing, in particular, two of them: the decision support systems and the innovative vehicles.

Methods

A questionnaire consisting of three main sections was administered to a sample of Italian farmers from North-West Italy (N=199). In the first section, participants were asked to choose between two main types of SFTs: drones and sensors and apps for data acquisition (SFT#1) and agricultural robots, autonomous machines and tractors equipped with electronic systems and sensors (SFT#2). Then, participants had to indicate if they agreed with twelve aspects which may hinder the adoption of the selected SFT. In the second section, participants had to rate how much some specific aspects proposed in the questionnaire should be improved to increase SFTs adoption. In the third section, a standard socio-demographic form closed the questionnaire. Descriptive statistics were computed for all variables of interest.

Results

The results showed SFT#1 significantly differ from SFT#2 in six out of twelve barriers. Thus, results highlighted more difficulties in implementing agricultural robots, autonomous machines and tractors equipped with electronic systems and sensors compared with the other technologies investigated. To overcome the existing difficulties in implementing the wider adoption of the technologies considered and to make farmers more aware of SFTs long-term benefits and reliability, more effort and targeted interventions are still needed.

Design of a Wireless and Digital-Based System for Obstacle Detection of Fixed and Moving Obstacles in Agriculture

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Keywords: Agriculture, tractor, safety, obstacle, run-over

Objectives

Obstacle detection in mechanised agricultural activities is a key element for safety management systems especially if workers on foot are required alongside tractors or farming equipment in order to complete a specific task. Both management of human- machine interferences and recognition of fixed obstacles require the identification of new methods and technologies that could succeed in providing early warnings and alerts to everyone involved in hazardous working conditions.

The project called “*Obstacle detection and tracking system for fixed and moving obstacles in agriculture*” (SIRTRack), funded and supervised by the Italian National Institute for Insurance against Accidents at Work (INAIL) in 2022, aimed to do so by designing a system infrastructure that intends to exploit the strengths of various wireless and imaging technologies in a multi-criteria approach.

Methods

System infrastructure relies on different technologies to sense hazardous conditions nearby a tractor: first, a map of fixed obstacles created through a Real-Time Kinematics (RTK) system in a field can be created and integrated by a Laser Imaging Detection and Ranging (LIDAR) distance analyses to identify fixed obstacles, while blind spot analysis will be performed through virtual and experimental tests; second, the presence of nearby workers on foot can be detected through the integration of Ultra-Wide Band (UWB) systems and live image analysis; lastly, a system for on-board alerts, Bluetooth Low Energy (BLE) notifications and procedures for emergency stops will be designed.

Results

A key aspect of the project is that the infrastructure has been conceived to merge all the information gathered by sensors and networks in order to extend the obstacle detection domain of every single specific system mentioned in methods. As a result, the fixed obstacles detection system can exploit additional data gathered by sensors mainly meant to serve the moving obstacles detection system and vice-versa, and in some cases even validate each other. Research consortium will continue to evaluate the efficiency of the designed system through tests in experimental farms, in order to meet the requirements of the whole detection framework and provide additional information for alert notification systems and emergency stop.

Water Management Sensing and Technology in Citrus Orchards

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Keywords: Sustainability, irrigation management, citrus stress, soil moisture content, fruit quality

Objectives

The reduction of water availability encourages the adoption of effective saving strategies supported by current technologies as a key tool for a sustainable citrus industry. Monitoring of soil moisture and plant status is necessary during the crop cycle. The combined use of proximal and remote monitoring of citrus groves seems to be the frontier of irrigation management.

Methods

The trial was carried out during the irrigation season (June-October 2022) in an orange grove cv 'Tarocco Rosso VCR' [*Citrus sinensis* (L.) Osbeck] grafted on Carrizo citrange rootstock [*Poncirus trifoliata* (L.) Raf. × *C. sinensis* (L.) Osbeck]. The monitoring was carried out both in field and remotely (Sentinel-2) at the experimental farm of the Research Centre for Olive, Fruit and Citrus Crops (CREA OFA) in Eastern Sicily, Italy (37°20' N, 14°53' E). Two treatments were compared: sub-surface drip irrigation system to replace 80% crop evapotranspiration (ET_c) (T2), dual drip line irrigation to replace 100% of ET_c (T4). The daily mean soil water content (SWC, θ_v) was measured with a probe above (15 cm) and below the subsurface drip line (40 cm) to monitor soil water content (HD35AP-S delta OHM, Italy). Satellite information was derived from available Sentinel-2 satellite products and the distribution map files of the reflectance values of these selected bands were processed by R software. In the observation period, 31 images were processed, and 25 of these were useful to calculate the NDVI index.

Results

A dataset for each spectral index was obtained, containing the information linked to longitude, latitude, and daily average for each treatment. The NDVI spectral index showed a similar trend between the two treatments, showing that a moderate water stress did not result in a reduction in the photosynthetic efficiency of the crop.

The soil water content fluctuations observed in the subsurface irrigation treatment at both depths were influenced by irrigation timing and volumes. Stress-irrigated citrus trees exhibited optimal soil water status, as revealed by θ_v values in the active root zone, which varied within the available water content. A moderate water stress is a sustainable strategy to save water, increase irrigation efficiency without altering yield and fruit properties.

ORAL PRESENTATIONS

TOPIC 12. Effect of landscapes on human health and welfare

A GIS-Based Model to Estimate Sheep Wool Waste Availability for Their Sustainable Re-Use and Valorisation

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Keywords: Circular economy, livestock waste, GIS, spatial analysis, environmental impact, sustainability

Objectives

Worldwide, several tons of agricultural waste are yearly generated, including livestock wastes (i.e., sheep wool), which create several critical environmental issues if not properly treated. In order to reduce the environmental issues related to the management and disposal, their use as natural fibre for green building component has notably developed over the last years. Indeed, sheep wool, which is a natural animal fibre coming from shearing sheep's fleece, is considered to be a problem of increasing concern for the complex and difficult disposal management. Recently, several researchers have demonstrated that "low quality wool" (i.e., not appropriate for textile uses) is suitable for thermal and acoustic insulation of buildings. In fact, thanks to its thermo-hygrometric and acoustic characteristics, it can be used as a reinforcing fibre for composite materials. In this study, a Geographical Information System (GIS)-based model to locate and quantify both the yearly amount of livestock waste, i.e., sheep wool, and the territorial distribution of sheep farms, through their GPS coordinates, was carried out and applied within the selected study area (i.e., Sicily region). The aim was to identify those territorial areas highly characterized by this kind of waste and therefore most suitable for localizing new shared wool collection centres to sustainably manage the reuse of this waste as potential green building component.

Methods

Data related to both sheep farms and sheep number were acquired and elaborated to obtain a tailored index that describes the level of availability of yearly produced sheep wool waste. The computation of the index requires the use of a set of indicators that must be previously defined and quantified by means of suitable databases and in-field surveys. Based on the index which is suitable to exactly provide information on the amount and location of sheep wool available for creating a new supply chain, spatial analyses were performed to obtain both thematic and heatmaps aimed at localising suitable collection centres.

Results

By GIS-based model results, suitable areas for locating the collection centres have been identified with the aim of valorising sheep wool waste for green building component, by minimizing the economic and environmental impacts. The achieved results could represent a first step to plan the sustainable re-use of wool waste as natural, renewable, and biodegradable fibre in the construction sector, providing the possibility of creating a new supply chain.

Landscape, Climate Change and Human Health. The role of Land Use in Sicily

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Keywords: Human health, climate change, landscape, agriculture, renewable energies

Objectives

Climate change is increasingly affecting human health and overall quality of life in multiple ways. Increasing temperatures have negative effects on aging population which is increasing exponentially in western countries. An increase of heat-related mortality and morbidity is the consequence of rising temperatures. Other indirect effects include diseases related to changes in water and food quality and quantity. According to World Health Organization (WHO) estimates, CC can cause an expected 250,000 additional deaths per year between 2030 and 2050. In addition, Climate Change would exacerbate disparities between rich and poor countries with further negative effects on human health. Mitigation and adaptation strategies are fundamental for reducing GHG emissions but their implementation poses relevant threats to territories. In order to increase the share of energy produced from renewable sources a growing amount of soil has to be used for implanting photovoltaic devices, competing with food production and affecting considerably the overall quality of the landscape. This is particularly relevant in Southern European Regions, like Sicily, due the favourable solar irradiation conditions.

Methods

The main focus of the study is the evaluation of current land use in Sicily, in order to assess the potentialities for implementing both mitigation and adaptation strategies. The possibility of implanting PV devices, by using existing developed land, minimizing the impact on landscape and agriculture has been evaluated, as well as the land that can be converted to new woods. The study is based on the available land use and technical maps. A sensitivity analysis has been performed using the criteria defined by the approved Regional Energy Plan (PEARS 2030). The proposed study will contribute to the lack of a detailed evaluation of this Plan.

Results

A careful planning of land use is fundamental for matching adaptation and mitigation with landscapes protection and food production. The proposed study shows the possibilities of implementing the PEARS objectives, using the vast amount of land already taken by infrastructure and settlements in Sicily in recent years.

ORAL PRESENTATIONS

TOPIC 13. Environment Safety, People Health Protection and Welfare

Hepatitis E Virus Detection in Swine Slurries of Abruzzo: Considerations on Virus Occurrence and Workers' Exposure

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Keywords: HEV, occupational exposure, foodborne viruses, waterborne viruses, zoonotic transmission

Objectives

Pigs and wild boars are the main reservoirs of the Hepatitis E virus (HEV). In Abruzzo, for most pigs, rearing occurs in a few specialised structures mainly devoted to animal reproduction and fattening. Following a recurring high prevalence of anti-hepatitis EIgG among blood donors, the *One Health* "FOOD-WAT HEV" project has focused on HEV presence in slurry samples from specialised rearing units to underpin the factors potentially affecting virus circulation in pig farms.

Methods

Four sampling campaigns were conducted in 19 intensive swine farming units throughout the Abruzzo Region in July, November 2021, and May and November 2022. Slurry samples were processed by concentration and nucleic acid extraction to detect HEV presence. Frequency analysis and binary logistic regression focused on any possible connection between breeding site characteristics, geographical location of the farm and HEV presence.

Results

HEV detection in swine slurry reveals substantial virus circulation throughout the Abruzzo territory: 18.9% of the collected samples resulted positive for HEV, 48.4% of which were from the sampling in May 2022. The χ^2 test revealed a significant relation between HEV detection and the housing structures with partly slatted floors, which were nearly fourfold more likely to provide HEV-positive slurry samples. Such findings underline the importance of good farming practices (i.e., adoption of biosafety procedures and rapid manure removal from the pens) as the first countermeasure to reduce workers' exposure.

Chemical risk management in agriculture and climate change: a review from a "One Health" perspective

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Keywords: Plant protection products, environment, health, occupational safety

Objectives

Climate change (CC) and weather conditions are strongly correlated and severely affect agriculture. To ensure an adequate food supply for the world's growing population, the use of crop protection products helps to maintain maximum productivity while minimising crop losses. The use of plant protection products has negative effects on human health as well as on the environment. Furthermore, extreme CC events can affect the distribution, transport and persistence of chemicals in the environment, potentially increasing the risk of water and soil pollution and consequently represents a major issue in terms of occupational health. As this is a complex and multifactorial topic, this paper aims to systematically apply an up-to-date review to critically evaluate the contributions of research articles that relate the two factors under consideration and summarise principles for sustainable resource management.

Methods

In order to obtain a comprehensive overview of the correlation between climate change and plant protection products, a bibliometric analysis was undertaken. Initially, the exploration involved the use of keywords such as 'climate change and chemical risk' or 'climate change and plant protection products', resulting in a substantial volume of relevant publications. However, given the heterogeneous nature of the topic, a text mining strategy was used, exploiting the capabilities of VOSviewer, a specialised software tool for bibliometric analysis. This made it possible to conduct a more comprehensive survey of the main areas of interest in the scientific literature. The data for this survey were extracted from scientific articles indexed in Scopus and Web Of Science. Subsequently, the search comprised two main components: a systematic literature searching and an in-depth literature review. The in-depth literature review served to further streamline the material and remove offline topics. For this purpose, we used the PRISMA (Systematic Reviews and Meta-Analyses) method. The combination of these two components made it possible to create a solid basis and provide a more complete answer to the research question.

Results

The literature review shows that there is a correlation between CC and chemical risk in agriculture. Higher temperatures can accelerate the chemical reactions and degradation of plant protection agents in the soil and environment, slowing their disappearance and prolonging their persistence. Heavy rainfall can favour the transport of chemicals used in agriculture to watercourses, aquifers and other

vulnerable areas, increasing their distribution in the environment. In addition, use of plant protection products is a well-known occupational health issue in agriculture.

In conclusion, CC poses a serious threat to the agricultural sector and, at the same time, agriculture has a key role to play in the fight against CC. To meet this challenge, the agricultural sector must adapt and adopt more sustainable and eco-friendly farming practices. This includes adopting climate-resilient crops, improving irrigation techniques and implementing smart farming systems that optimise the use of resources. Promoting sustainable cultivation practices can also help reduce greenhouse gas emissions.

A Survey on Drivers' Health Impact of Pollutant Gaseous Emissions of Agricultural Machinery

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Keywords: Agricultural machinery, diesel engine, gaseous emissions, drivers'health

Objectives

The literature available worldwide has largely proved in the last three decades the dangerous impact on the environment of the gaseous emissions of the internal combustion engines, especially of Diesel type. In fact, they are producing a high amount of particulate matter (PM) and nitrogen oxides (NO_x). More in detail, a high concentration of PM increases the smog and the acid rain and makes worse the atmospheric visibility. A high production of NO_x cause likewise a raising of the acid rain, as well as promotes the accumulation of nitrates on the ground, which can significantly alter environmental ecological balances. Apart the environmental impact, several studies highlighted also a clear correlation between Diesel engine emissions and chronic diseases of the human respiratory system. Symptoms ranging from rhinitis and asthma to carcinogenic effects due to the long term inhalation of unhealthy air have been frequently reported. On the other hand, the coming in force from 1996 of anti-pollution regulations concerning the engines fitted on non-road machinery (included agricultural tractors and self-propelled machines), have hugely decreased the dangerous gaseous emissions. In detail, the fitting of these systems dedicated to diesel engines reduces mainly the production of NO_x (due to a high combustion temperature), and of PM, caused on the contrary by poor combustion conditions. Nevertheless, in Italy the agricultural tractors are as an average about 27 years old; this means that the engines of many of them are not equipped with any anti-pollution device, so producing huge amounts of dangerous emissions.

Methods

With reference to what ascertained in the medical literature concerning the workers' health, the main purpose of this study has been the measurement of the real gaseous pollutant emissions of diesel engines fitted on self-propelled agricultural machinery and then to compare the concentration values obtained with the danger limits established. The usual running conditions for the various operations carried out by the machinery in the field were simulated at fixed-point, by means of an electromagnetic brake (for example applied at the tractor PTO), applying suitable torque values, after the setting up of the nominal engine speed. Later, some usage scenarios have been created, to evaluate the overall impact of the pollutants on the driver's health.

Results

The emissions of the older tractors resulted much more dangerous for PM production, while recent models require attention for NO_x levels, frequently found remarkably exceeding the limits provided by the dedicated standards.

Has the Risk of Agricultural Tractors Overturning Changed in the COVID Period?

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Keywords: COVID, tractor, overturning, accidents, manpower

Objectives

Above all between 2020 and 2022, a large part of the population of our planet was devastated by the terrible COVID pandemic, causing millions of victims. For more or less time, habits and lifestyles of the people were deeply changed, also as regards work, with a high increase of smart-working. This upheaval did not affect, if not indirectly, the agricultural activity that was, is and will be always strictly linked to natural cycles, that is to crops production, livestock farming, forestry activities and of course to the succession of seasons.

However, considering that in the developed countries the agricultural activity is frequently based on part-time workers, it may be the engagement of manpower for cultivation processes has significantly evolved during the pandemic, especially in the lock-down periods. In fact, the forced closure of the industrial and service sectors, and consequently the longer time possibly devoted to other activities, may have more or less temporarily increased the labor carried out by people not highly skilled in using machinery. As a consequence, also the most dangerous risk factor of agricultural machinery, the tractor overturning, could have registered an increase.

Methods

Since 2008 an independent observatory was established at DISAA-UNIMI on accidents due to tractor overturning, by examining many web portals of news to extract the maximum information detail from these sad events. The data obtained are then systematically implemented and compared with those regarding statistics on agricultural land, manpower and tractors use.

The combined data coming from the previous period were so compared with those concerning the pandemic years 2020, 2021 and 2022.

Results

In the surveyed period, the recorded number of fatal tractor overturning did not fall outside the consolidated range of previous period (approx. 100 to 140 accidents), but the average age of the victims decreased, so confirming a more intense working activity of younger population, probably temporarily engaged in the COVID lock-down periods.

Preliminary Results on the Correlation Between Drop Size, Foliar Deposition and Surface Coverage to Reduce Agrochemical Use

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Keywords: Drop diameter, liquid immersion method, water sensitive papers, image analysis, imagej

Objectives

Drop size spectrum is one of the most important factors affecting environment and operator safety during spray applications of agrochemicals. In fact, drop size affects environmental pollution in terms of off-target losses due to evaporation, drift, and run-off, as well as operator safety due to its effects on dermal and inhalation exposure. In addition, drop size also affects foliar deposition and surface coverage, so affecting all aspects of a phytosanitary treatment. The main objective of this research is to study the correlation between drop size, foliar deposition and surface coverage under laboratory conditions.

Methods

Experimental tests were carried out by using a custom test-bench purposely designed and built to measure the drop size spectrum from hydraulic nozzles by exploiting the liquid immersion method. The test-bench reproduces a standard commercial sprayer and essentially consists of a transportable trolley carrying a 70 L tank, a diaphragm pump driven by an electric motor, a manual pressure regulator, and a spray boom carrying one multiple nozzle holder. The spray boom is applied to a mobile support that moves along two slides placed above and parallel to the plane of the trolley, at a distance of 0.5 m. The whole system is managed by a custom software user interface that allows controlling the spray boom movement, starting and stopping spraying, registering pressure and nozzle flow rate. According to the procedure described in the ISO 5682-1 standard, the test liquid (a mixture of water and food dye *Red Poinceau*) was sprayed above three Petri dishes containing silicone oil. The drops captured inside the oil were photographed in situ by a high resolution DSLR camera and then the images were analyzed by using the *ImageJ* software so measuring all spray drop diameters and the spray features. Moreover, three Water Sensitive Papers (WSP) and six orange leaves were placed next to the Petri dishes during the spraying tests. This arrangement allowed to measure at the same time drop size spectrum, superficial coverage on WSP, and foliar deposition on orange leaves by using a spectrophotometer.

Results

Data analysis is still in progress. Expected results will allow drawing the first correlations between drop size spectrum, superficial coverage and foliar deposition, useful to reduce pesticide use and safeguard environmental and human health.

ORAL PRESENTATIONS

TOPIC 14. ROPS and Stability Research

Assessing the Physical Mismatch Between All-Terrain Vehicle Controls and Youth Strength: Implications for Agricultural Safety

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Keywords: ATV, farms and ranches, physical capabilities, youth injury prevention, quadbike

Objectives

This study aims to assess the potential discrepancies between the required activation forces of the controls of 54 utility ATVs and the strength of male and female youth of varying ages (6-20 years old) and strength percentiles (5th, 50th, and 95th). In addition, we also assessed if youth strength is enough to push the ATV off if they are pinned underneath it, which is a common post-rollover scenario that can result in death by mechanical asphyxia.

Methods

To achieve this, the activation forces of the ATVs' controls were measured experimentally, while the corresponding strength of the youth was obtained from literature sources. A handheld force gauge, a button load cell, and a pressure glove were used to measure the activation forces of the main controls (handbrake, footbrake, handlebar, throttle lever, ignition switch, headlight switch, hand gearshift, and foot gearshift) of the utility ATVs.

Results

The findings of this study reveal a physical mismatch between the forces needed to operate the ATV controls and the strength of the youth, thereby compromising their ability to ride ATVs safely. The most challenging ATV operation tasks for the youth were pressing the footbrake and pushing the ATV off (if pinned underneath it). For instance, youth aged 6-10 would be able to activate the footbrake of only 64% of the evaluated ATVs. The inability to depress the footbrake affects the youth's ability to reduce the speed or stop the ATV and can prevent the operator from diverting from obstacles or potential bystanders. The results were even more striking when considering the ability of a youth operator to push the ATV off if pinned underneath it. Less than 13% of all evaluated vehicles could be pushed off by male operators aged 16-20 years old of the 95th strength percentile, the strongest subjects of this study. The observed discrepancies between ATV controls and youth strength put young riders at an increased risk of crashes.

Assessing the Impact of Friction and Speed on Actuation Forces of Foldable Roll-Over Protective Structures

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Abstract

The number of fatal tractor accidents where the Foldable Roll-Over Protective Structure (FROPS) was not properly deployed has increased greatly in recent years. Drivers often leave the FROPS in a folded-down position because raising and lowering it is difficult and time-consuming. The force required to raise and lower the FROPS is not well known. In this study, we examined the factors that affected the force required to operate the FROPS and quantified their effects. We found that the force required to operate the FROPS is influenced by its shape, size, material density, turning acceleration, speed, and friction. To evaluate the effect of each factor on the force required, we measured the force required to operate 12 FROPS from 6 different models. We used a variable speed motor system to control the speed of raising and lowering the FROPS and to evaluate the effect of speed on the force required. We also measured the force required to operate seven FROPS from the same model before and after applying grease to evaluate the effect of friction on the force required. Additionally, we developed a theoretical model to predict the force required based on the FROPS shape, size, and material density. Our results showed that friction has a significant effect on the force required to operate the FROPS. The friction varied greatly between different FROPS of the same model, ranging from 0 to 212%, due to differences in manufacturing and maintenance. We also found that speed has a significant but relatively small effect on the force required to operate the FROPS. Although statistically significant differences were observed between different levels of speed, the differences were negligible.

Applicability to Narrow Track Tractors of an Official Standard for the Calculation of Self-propelled Agricultural Machines Stability

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Keywords: Safety, overturning, lateral limit angle, narrow-track tractor

Objectives

Tractors overturning remains one of the major causes of fatal accident in agriculture. From many decades, ROPS is the protection device applied worldwide to reduce the risk for the driver, but in any case the development of tractor models showing the highest stability is considered the best approach right from the design stage. Concerning the agricultural tractors overturning, the standards actually in force do not specifically consider a proper method for measuring the maximum lateral stability angle. Nevertheless, for industrial and earth moving machinery some standards dealing with the ascertainment of their stability are in force by time. Moreover, and more in detail, ISO 16231 standard is dealing with a method for calculating the rollover angle of the so-called "self-propelled agricultural machinery", requiring the management of geometric measurements only. In this study, a number of different tractor models, mainly narrow-track, were tested on a tilting platform to evaluate their lateral stability. The results were compared with those obtained by applying the ISO 16231 standard, to verify the possible development of a simple method suitable for agricultural tractors.

Methods

Five wheeled tractor models were tested to ascertain their lateral overturning limit angles. The results were compared with those later obtained by following what stated in the ISO 16231 standard. If equipped with a pivoting front axle, the tractor is characterized by two different overturning angle values. The first is measured when the upstream rear wheel loses the contact with the support surface, and the second (greater than the first) occurs when also the front upstream wheel is raised from the platform. Both rollover angles were recorded and analyzed, also to calculate the difference between the two values.

Results

The application to the agricultural tractors of ISO 16231 highlights a possible successful approach, even if some limits were evidenced, due to some different machine features, i.e. the mass distribution on the axles. As a consequence, some additional characteristics influencing the applicability of this standard need to be deeply investigated, in order to develop a theoretical model for ascertaining effectively the lateral tractor stability.

Experimental Validation of the Influence of Obstacles on Tractor Rollover Stability

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Keywords: Tractor safety, rotating test-rig, stability map, CoG determination

Objectives

Tractors rollover, with its nearly 140 fatal accidents each year in Italy (about 10% of which located in South Tyrol), represents one the major safety issues in farm activities. The risk increases when tractors operate in critical conditions such as a mountain environment, where slopes and the presence of ground obstacles reduce the rollover stability margin. Therefore, the development of stability models and simulators to study the behaviour of existing vehicles operating in hazardous conditions results very important, especially if they are originally designed to work on flat surfaces. However, the validation of these models is still a challenge as they must be compared and calibrated with experiments on real machines (i.e., too much complexity in working with bulky and heavy machines even from a safety point of view).

The aim of this study is the development and experimental validation of a mathematical model to predict the behaviour, in terms of static stability, of a tractor travelling a slope with different directions and in presence of different terrain conformations.

Methods

A four-wheel-drive narrow-track tractor (New Holland TN75V) is considered as a test case. Firstly, a mathematical model of static rollover stability was derived to predict all the instabilities for any orientation of the machine and any terrain conformation (i.e., presence of potholes or bumps). The results are then compared with an experimental test campaign performed on a real tractor and taking advantage of an innovative vehicle stability test rig available at the Agroforestry Innovations Lab (AFILAB) of the Free University of Bozen-Bolzano. This facility consists of a rotating and tilting platformable to orientate a tractor under test (up to a weight of 10 tons) in any direction and tilt it up to the rollover instability. Then, the four independent plates that support the tractor wheels can be vertically shifted to emulate an uneven terrain. During the test, a series of load cells integrated under each of the four plates measure the wheel-terrain contact forces in real-time.

Results

The result of this work is a series of stability maps showing how the presence of obstacles and the way they are passed over by the tractor can both worsen and improve the instability condition. Moreover, the experimental verification carried out on the real tractor considering different orientations, obstacles configurations and the way in which they are overcome, showed the validity of the developed theoretical model.

Semi-quantitative Risk Assessment Framework for Tractor Rollover Prevention Systems Based on the Functional Resonance Analysis Method (FRAM)

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Keywords: Agriculture, tractor, fram, safety, SQRA

Objectives

Tractor stability is the most important factor in safety assessments of mechanised agricultural activities. Research has explored, in the past, the variables which negatively influence stability which prompted the definition of methods for detecting tractor rollovers and providing new protective devices, as well as monitoring and alerting tools. This research aimed instead to define a framework capable of identifying latent dangerous working conditions in which common root causes of rollover would not be enough to generate an accident on their own.

Methods

The Functional Resonance Analysis Method (FRAM) is one of the latest tools for resilience engineering and suits the “Safety II” approach in which systems are reliable only if they can manage to overcome issues derived by variable working conditions. In contrast with other safety analysis methods, FRAM allows to define the degree of anomalies, breaks down an activity into basic functions and identifies hazardous couplings among those working conditions that can lead to accidents. Since agricultural activities can be described by a small number of basic functions and background environmental conditions can be forecasted, the variability of an activity can be determined by tractor performance data, environmental conditions and sensors such as accelerometers and tools like global navigation satellite systems (GNSS).

Results

Authors identified four scenarios which describe potential working conditions that can arise in the field: a) Thoroughness, the most precise way; b) ALARP (as low as reasonably possible) conditions, which keep into account socio-economical aspects; c) Compliance, which describes how an activity should be carried out according to the law; d) Effectiveness, which describes the fastest way to carry out the activity. In addition, accident analysis from case history has been performed. Data has consequently been collected from the vehicle and the environment to classify real-time activities into one of the four scenarios of the framework, allowing to send notifications regarding hidden sources of hazard to the tractor’s driver and, at the same time, send information to a remote server for eventual definition of additional risk mitigation countermeasures. Future development might include more detailed quantifications and a wider range of risk assessments.

An Evaluation of Operator Perception in Manual Handling of Front Foldable Rollover Protective Structures Mounted in Narrow-Track Tractors

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Keywords: Operator safety, agriculture, ROPS

Objectives

Despite the progressive reduction of agriculture fatalities, accidents data is still alarming with 217 deaths per year, more than 60% of which involving tractor rollover with the crushing of the driver for lack of protective devices. The folding version of front roll-bar (Foldable, Rollover Protective Structures, FROPSs) has been designed to allow tractors to operate in low overhead clearance conditions. However, due to the discomfort in FROPS handling, the farmers often leave them in the folded-down position. Concerning this unsafe behaviour and considering the growing female role in agriculture activities, the present study aimed to evaluate the perceived difficulty by users in handling the FROPS considering: *i*, gender of the user; *ii*, FROPS mass; *iii*, skillness level in using the tractor (expert, occasional or novice user).

Methods

Five narrow tractors were evaluated. The tractors were all fitted with front foldable ROPS with a mass ranging from 17 to 55 kg.

A test panel, mainly composed of skilled drivers, was selected to perform an evaluation on the handling of foldable ROPS. The test panel was composed of 31 operators, 20 men and 11 women. A survey was submitted to the test panel and it was analyzed with Kruskal-Wallis Test to evaluate if the easier, quicker and safer handling of the foldable ROPS are affected by the operator.

Results

The results denoted a different perception in the FROPS handling between male and female operators. In detail, expert male operators were mainly able to perform the FROPS handling but the ROPS mass affected the operation. For the female group it was clear that independently on the ROPS mass the FROPS design did not allow the manual handling denoting a non-ergonomic design approach.

Survey on the Stability of Tractor-Implement Combination on Increasing Slopes

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Keywords: Slope, 3-point linkage coupling, static overturning angle, tilting platform

Objectives

The static stability of various combinations of tractors and implements carried at the 3- point linkage was analysed on a tilting platform, by placing the machinery in various positions in respect to the slope, and by varying both the height from the ground and the distance of the centre of gravity of the implement from that of the tractor. The goal was to verify the variation range of the Static Overturning Angle (SOA) by simulating the main common machinery situations when working on slope, to ascertain the most critical conditions affecting the stability.

Methods

Agricultural tractor overturning is the main cause of fatal and/or heavy disabling accidents. For this reason, many studies were carried out and several regulations were issued by time, to highlight the most critical conditions (i.e. the stability limit angles) concerning the tractor overturning. However, in this scenario the tractor is frequently taken into account without implements; but in all the field working condition tractors are always coupled with one or more implements, so modifying (sometimes remarkably) the stability conditions, mainly due to the mass and the centre of gravity location of the implement. More in detail, the stability becomes worse when the implement is coupled at the 3-point linkage; the mass of the implement plays an important role, as well as its centre of gravity location, above all in respect to the height from the ground and the cantilever to the tractor rear axle. On a flat tilting platform, a number of tractor-implement combinations were placed in different positions in respect to the slope. The implements, having different mass and dimensions, were moved at various height from the ground of the tractors 3-point linkage.

Results

As expected, the coupling of an implement to the rear of the tractor worsens the longitudinal SOA; the situation of lateral stability requires a careful assessment: in fact, the height variation of the implement from the ground and/or its distance from the tractor could lead to an improvement or a worsening.

A Fully-Assisted Folding Rear Rollbar for Agricultural and Forestry Tractors: the QROPS

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Keywords: Overturning, ROPS, management automation, electric linear actuator

Objectives

Statistics from recent decades confirm that the ROPS (Roll Over Protective Structure) has proved to be the most effective device for decreasing victims due to agricultural and forestry tractors overturning, which in Italy still counts from 100 to 140 fatal events per year. However, there are still some problems, which if resolved could decrease this tragic figure. One of these concerns the correct handling of 2-post folding rollbars, installed both front and rear at the driver's seat. These ROPS can alternatively assume a protection and a rest position; the latter should be activated only in well defined situations, i.e. when normal operation does not foresee a significant decrease in the machine stability. Unfortunately, due to distraction, negligence or laziness, operators often do not return these ROPS to the protection position, thus completely negating the effectiveness of the device. Recently some progress has been made to facilitate a correct management of these ROPS, for example with the application of gas springs able to significantly reduce the handling force, but the execution of the entire routine has remained fully manual. Therefore, the automation of the operation would bring a great advantage for operators, both in terms of fatigue and especially of time, motivating them more to manage correctly the ROPS handling. In the past, various facilitation solutions have been developed, with increasing levels of automation; although fully viable, they have proved to be too expensive. It would therefore be necessary to set out simplified devices, cheap and effective, available also for retrofitting.

Methods

The QROPS is a 2-rear pillars frame with 3 hinged sections, which thanks to a four-bar linkage can switch from a rest condition, where the 3 sections are placed "packaged" in a horizontal position, to a protection condition, when the sections are moved vertically by means of two linear electric actuators powered by the tractor battery. The mechanical locking of the hinged points is assured by hooks and ratchets, with the help of a series of return springs.

Results

The functionality of the prototype has been primarily ascertained in terms of its performance: in 7 s the rollbar completes the transition from the rest to the protection position, thus proving suitable for a semi-automatic handling, manually controlled.

Obviously, the prototype was also validated from the point of view of its robustness, having successfully passed the strength tests provided in OECD Code 4, for a tractor with a reference mass of 3200 kg.

Compact Tractor 4.0: an Investigation for the Development of a Low-Profile Full Electric Specialized Tractor

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Keywords: Agriculture 4.0, safety, electric power, efficiency, zero emission

Objectives

The main goal is to define a path for the development of a low-profile full electric specialized tractor. The prototype, properly arranged to support the agriculture 4.0 technology, will be equipped with a fixed protective structure in case of overturning (ROPS), suitable to reduce the overall height of the machine while effectively protect the driver in all working conditions. The machine will be in line with the technical and homologation requirements of EU regulation 1322/2014 and set up to pass successfully the steps provided by the standard procedure.

Methods

The research was initially aimed at a survey on the power required for the most common tasks carried out by a tractor used in vineyards and orchards. As a reference a medium- high model in the category (100 CV, 73.5 kW) was taken into account, having the following general features: traditional mechanical gearbox, hydraulic system driven by a gear pump always running (efficiency 0.96) and a mechanical PTO (efficiency 0.95). The boundary conditions involved flat work and a good bearing capacity.

Another important step of the project was dedicated to contain the overall dimensions of the machine, especially in height. To assure proper ergonomic requirements, reference was made to the European regulation 1322/2014; on the other hand, for those of safety to the standard ISO 4254-1 and to the OECD Codes 4 and 7.

Results

The global power needed has concerned the requirements for traction pull, and those for PTO and hydraulic outlet. The heaviest conditions were recorded in plant protection products distribution (carried out with a pneumatic sprayer, 99% of the available power) and subsoiling (80.4%). Concerning the overall dimensions, in addition to a possible minimum front and/or rear track less than 1150 mm (in such a way to classify the prototype as narrow tractor), it should be advisable to maintain a maximum height of less than 1550 mm and to assure a ground clearance of at least 250 mm.

ORAL PRESENTATIONS

TOPIC 15. SHWA & Augmented reality, Gamification, IoT

IoT LoRaWAN Device for Measuring Electrical Consumption in Agricultural Sector: Installation in Dairy Farming and Greenhouse Floriculture

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Keywords: Remote monitoring, energy, dairy production, AFS

Objectives

The livestock and greenhouse sector are considered "energy-intensive users" and have been affected by the general increase in prices making very important to monitor and optimize the energy consumption.

Methods

The research group developed a purpose focused IoT device based on LoRaWAN technology for measuring electrical consumption. The device consists in: i) current clamps CT at 50A/1V; ii) Arduino Mega to connect CT sensors and sending value to gateway; iii) Gateway LoRaWAN based on Raspberry Pi3 connected to a developed private cloud platform, sending data by a SIM; iv) Cloud platform; v) Electrical panel with safety circuit breakers and 12V backup battery. Energy consumption was calculated using a specific formula which consider the $\cos \varphi$ and the voltage for each line to monitoring, measured by external instrument. Consumption monitoring can be viewed online by a dashboard based on Node-Red framework. The installation of the instrumentation took place in two different Italian agricultural facilities: the first one is set up to greenhouse floriculture heated by compressor heat pump located in Pescia (PT), Tuscany, for 110 days; the second one took place in a dairy cattle farming located in upper Po valley (BG), Lombardy, for 48 days.

Results

The device is programmed to continuous reading CT sensors and sending the average each minute by LoRaWAN. The device correctly sent and stored data during the period of measurement to a remote database and no connection and data loss problems were encountered. The access of dashboard is protected by login, the data are stored into a Mysql database not exposed directly in web. The data transfer recorded during the experimentation is about 8MB/day. It can be stated that this technology is a valid tool for monitoring consumption for farmers and provides valid support for business choices (smart decisions) and to reduce energy consumption.

Gamification for Safe and Innovative Agriculture

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Keywords: Gamification, IoT, simulator, augmented reality

Objectives

Many farming simulator games are on the market, some of which are also well done, that prove the trend of people to learn playing. The games offered on the market have highly playful characteristics, but little truthfulness and physical correspondence with real situations, especially the realistic behavior of the tractor. To obtain a nice correspondence between the virtual simulator and the real tractor, we need to accurately capture the data of the vehicle's behavior in the field.

Our goal is to obtain a high one-to-one correspondence, meaning that if we play with the simulator, it is as if a real tractor moves, and if we drive the tractor on the field, we get the same results on the simulator.

Methods

To achieve our target, we create a method based on IoT, mainly with gyroscopes, to understand how the tractor steers according to the movement of the steering wheel, simultaneously detecting the exact slip of the wheels during movement, using a GPS- RTK extension.

Having achieved this result, we pass on to reliable remote guidance tools; and by implementing the real tractor with additional safety systems we introduce elements of Augmented Reality into the remote driving system.

Results

Implemented a method for sampling the real behavior of the agricultural tractor using GNSS-RTK and Gyroscopes.

Co-Designing Game Training Solutions to Improve Safety in the Agricultural Sector: Insights for the Correct Use of Foldable Roll-Over Protective Structure

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Keywords: Digital training, farmers' safety, ergonomics, co-design, brainstorming

Objectives

Promoting the correct use of Foldable-Rollover Protective Structure (FROPS) could significantly reduce the rate of injuries due to tractor roll-over accidents. Recently, multimedia technologies, including the application of gaming components during learning activities, have allowed the development of a more engaging form of safety training and education. Based on this, the aim of the ongoing project is to develop a prototype of a gamified tool based on ergonomic requirements to train farm operators in identifying tractor rollover-related hazards and correctly operating the FROPS. The present contribution describes the co-design process and reports the first results obtained.

Methods

An ergonomic participatory approach was used to co-design the graphic content and features of the gamified training tool. One workshop and brainstorming session was conducted with four students from the Departments of Agricultural Studies of the University of Torino. The session lasted about 3 hours, and it was structured into two main phases (called "100 images and sticky notes" and "Storyboard"). These sessions allowed, respectively, to detect funny and motivating game elements that can be used to create the digital visual interface and to define the storyline that players/workers would like to see/play in the game.

Results

The results showed that workshop activities supported participants to be collaborative, effective, and creative. In particular, eight main game features were highlighted and defined during the co-design sessions: the open world (i.e., an open area in the game where the player can explore and approach objectives freely), customization, hit points, maps, time, graphic, quiz, dialogue with non-player characters. Based on the present results, a list of user-centred requirements is developed to design an attractive prototype of a gamified training tool aimed to enhance the current use of FROPS and prevent injuries or fatal consequences in case of roll-over accidents.

POSTER PRESENTATIONS

TOPIC 2. WMSDs Work related Musculoskeletal Disorders

Whole Body Vibration Transmission to the Human Rachis in Agricultural Tractors

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Keywords: MEMS accelerometer, risk assessment, safety

Objectives

The seat has always been an element to intervene on, to improve the vibrational comfort on agricultural tractors. Over the years, it had a remarkable evolution arriving today at active or semi-active suspension systems, capable of monitoring vibrations and adjusting the stiffness of the suspension in real time.

There are several methodologies for assessing the level of exposure to Whole Body Vibration (WBV) such as ISO 2631 and ISO 7096. They limit the assessment of vibrations to the seat-buttock and back-lumbar interfaces, neglecting to assess the propagation of vibrations throughout the rachis.

In this paper, the transmission of vibrations along the rachis was measured in drivers of agricultural tractors in order to evaluate whether the only measurements carried out according to ISO 2631 and 7096 were adequate to describe the effective level of exposure and how the regulation of seat can affect the transmission of vibrations from the machine to the operator.

Methods

An acquisition system based on ADXL345 MEMS accelerometers and an Arduino UNO microcontroller was suitably developed to acquire the vibrations in several points along the spinal column in addition to those indicated by the reference standards. Specifically, five MEMS accelerometers were placed at the seat attachment point, the seat-buttock interface, and along the drivers' column. The tests were performed on tractors equipped with different types of seats, used on different routes: paved road, dirt track, field.

Results

The results showed that the assessment of the level of exposure to WBV according to ISO 2631 and 7096 does not always describe the actual value, that in any case the adjustment of the seat suspension is essential and low-cost systems such as the one developed in this study can be used to monitor the level of vibration exposure of agricultural tractor drivers.

POSTER PRESENTATIONS

TOPIC 3. Machine Milking, Animal Welfare, Sustainable livestock farming

Monitoring Milking Process Variation Using Model Driven Multivariate Control Charts (MDMVCC)

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Keywords: Milking process, dairy cow, model driven multivariate control charts

Objectives

Proper milking procedure is required to ensure good management of the milking parlour to milk cows gently, rapidly and completely (Tuor et al., 2022). Additionally, milking efficiency is mainly influenced by parlour performance, the number of milking units, operator work routine, individual cow production and associated duration of unit attachment to the cow (O'Brien et al., 2012). The objective of the work was to define model driven multivariate control charts of the milking process in three different milking parlour types and to compare their efficiency when they were in and out of control data points.

Methods

Milking performance data were collected from three milking parlours (1 herringbone, 1 parallel, 1 rotary). The number of milking stalls were 15+15, 16+16 and 36 respectively for the herringbone, parallel and the rotary milking parlour. Common conditions to all the systems were the electronic identification of cows using RFID technology, the use of milk meters to measure milk yield for individual cows, the adoption of the same herd management software (AfiFarm v. 3.07, Afimilk, Afikim, Israel), and the vacuum pumps driven by variable speed drive units. The working parameters for all the milking parlours were 42 kPa system vacuum, 60 cycles/min pulsator rate, and 60 % pulsator ratio.

The following variables of the milking process were considered:

1. average milk flow rate [kg/min]: it is a good barometer of the overall milking event, as it takes into account both the level of cow stimulation during preparation as well as the effect of automatic cluster removal thresholds for detaching the unit (Stewart et al., 2001). Moreover, the results are comparable between brands and parlour designs (Treichler and Reid, 2013);
2. average milk yield at the first two minutes of milking [kg]: because two minute milk is driven by our interactions with the cow during preparation procedures and cow handling, it can be

used as a reliable indicator of events leading up to unit attachment as well as early duration (Treicheler and Reid, 2013);

3. low flow (below 1 kg/min) time [min]: poor premilking udder preparation, milking routine (e.g. manual milking mode), and improper automatic take off settings can increase time in low flow (Wieland et al., 2016); average milk yield/cow [kg];
4. multiple attachment [n];
5. irregular take off [n]
6. milk yield/stall per hour [kg].

Data relative to the morning milking session were extracted from the herd management software of each milking parlour. Multivariate control charts for the historical values of milking process variables 1 to 6 were built using the Model Driven Multivariate Control Chart (MDMVCC) platform of JMP Pro ver.16 statistical software (SAS Institute Inc., Cary, NC). For a set of continuous variables, the MDMVCC platform uses principal components to build the control chart.

Results

Average number of milked cows with standard deviation was 305 ± 20 , 275 ± 16 and 834 ± 51 in herringbone, parallel and rotary milking parlour, respectively. Milking duration with standard deviation was shortest in the parallel milking parlour 2.5 ± 0.2 h which applied full milking routine with two milkers while longest was in rotary milking parlour with three milkers 5.9 ± 0.5 h. In the herringbone milking parlour, the number of the milking processes analysed was 356 out of that 325 were in control while 31 were out of control. When compared milk produced per stall per hour, we found statistically significant higher milk production ($p < 0.01$) when the system was in control (31.1 ± 3.2 kg) than out of control (29.2 ± 4.0 kg). A bit higher significant difference ($p < 0.01$) was found in the rotary milking parlour with milk per stall per hour production when data points were in control (49.6 ± 5.6 kg) compared to the situation when they were out of control (44.9 ± 5.3 kg). The highest significant difference ($p < 0.01$) was found in the parallel milking parlour where milk produced per stall per hour when the data points were in control was (61.1 ± 7.2 kg) compared to data points out of control (54.3 ± 7.0 kg). These preliminary results suggest that the proposed MDMVCC is a potentially useful tool to detect milking process variation in each of the three investigated milking parlours. Additionally, values of the milk produced per stall per hour were significantly higher when the milking process was in control compared to the situation when it was out of control.

Dynamic Chamber Technique to Measure Ammonia and GHG Emissions From Traditional and Vegetal Cats' Litter.

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Keywords: Cat's litter, odor control, ammonia, GHG, emission

Objectives

Nowadays, cats are pets present in most of the European and American houses. The home management of these animals requires the use of litter boxes for their physiological needs [1].

However, these litter boxes are often a source of odours and a source of frustration for both cat owners and the animals themselves.

Unpleasant odours from litter boxes derive from urine and faeces [2] since ammonia is produced by the action of microbial ureases on urea.

Controlling cat urine odour is particularly challenging, because cat urine is among the most concentrated of animal species, for the high percentage of ammonium ions and urea contained in it, caused by a high protein diet [3].

Although over the years various types of litters have been developed to remediate this problem, in reality, most of these litters do not allow the real reduction of odor emissions but simply allow unpleasant odours to be masked with fragrances or particularly absorbent materials such as coal and bentonite clay [4].

In this study, a traditional clay-based litter (C) was compared with a vegetal barley-based clumping litter (Greencat Barley, Greencat SRL, Segrate), added with a pool of probiotics, tested in two different concentrations (T1 and T2), using a dynamic emission chamber [5] for measuring ammonia, methane, nitrous oxide and carbon dioxide emissions.

Methods

Thirty samples were collected during the study, i.e. thirty "balls of litter with urine", 10 from litter C, 10 from T1 and 10 from T2. The samples were collected and stored in a freezer at -20°C until the time of analysis.

Subsequently, the samples were thawed, mixed. From each sample, 2 sub-samples were of 1 g were obtained, finally their ammonia, methane, nitrous oxide and carbon dioxide emissions were evaluated, at 20°C in the laboratory.

For the emission evaluation, the dynamic chamber system was used, using containers with a volume of 44.16 cm³ as emission chambers. For each sampling session, the amount of 1 g of mixed substrate covered the base of the container with a single layer of litter granules (surface of 4.9 cm²). This part of the protocol was assessed considering that the ammonia emission depends on the size of the emitting surface.

The measurements procedure was performed using a BK1512 gas analyser lasted 10 minutes, the time necessary for the decay of the ammonia to at least 100 mg/m³ of the control litter, at a frequency

of 1 minute. The total amounts of gasses emitted in the 10 minutes were considered, in the statistical analysis.

The odour of the litters was defined by 6 people involved, who assigned a score, using a scale from 0 to 10, where 0 is a non-existent odour, while 10 is a persistent ammonia odour. The data collected were subjected to analysis of variance (Proc GLM, statistical package SAS 9.4, 2020), to evaluate the emissive difference of the 3 litters.

Results

The results show that the standard litter had a higher average ammonia emission, 228.57 mg/m³ vs 9.41 mg/m³ of T1 and 6.18 mg/m³ of T2 (P<0.001). In line with the measured ammonia values, the concentrations of nitrous oxide were significantly higher in the control litter (0.820 mg/m³ for C vs 0.737 mg/m³ for T1, P<0.001 and vs T2 with 0.731 mg/m³, P<0.001).

The methane emitted was instead lower in the control (0.244 mg/m³) than in T1 (1.511 mg/m³, P<0.05) and in T2 (P<0.01), also T1 methane was significantly different from T2 methane (1.151 mg/m³, P<0.01). The carbon dioxide emitted, which was also higher in the control (P<0.001).

The results obtained, were confirmed by the scoring attributed to the three different litters for the odour produced, Litter C presented a mean score of 10, Litter T1 a mean score of 3 and Litter T2 a score of 1.

In conclusion, the standard litter C showed a much higher mean ammonia emission than the two treated ones, T1 and T2 (P<0.001), which presented almost no annoying odours. The barley-based litters with different supplements, T1 and T2, have shown a better efficiency in the mitigation of ammonia emissions, of other gases and of odours.

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POSTER PRESENTATIONS

TOPIC 7. Agriculture 4.0, Automation, Remote Control, Robot and Innovative Vehicle

Variable Rate Fertilisation of Orchards to Reduce Environmental Impact: a Mini-Review

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Keywords: Precision agriculture, fertilizer spreader, agriculture 4.0, digitalization, environmental issues

Objectives

The shortage of mineral nitrogen fertilizers and the sharp rise in prices are putting crop fertilization programs at great risk. To deal with the situation, it is necessary to intervene in the short and medium-long term, including by adopting the principles and techniques of precision agriculture. Variable-rate fertilization techniques are expanding due to the possibility of using fewer resources and minimizing the environmental burden. The aim of the paper is to present a mini-review on the techniques and machines used in variable rate fertilization by analysing the experiments conducted in the last 10 years.

Methods

The methodology involved several steps. A first phase concerned the definition of the field of investigation; the next phase was dedicated to the selection of research papers on the Scopus database and the last phase was addressed to the study and the analysis of results of the research conducted on the subject.

Results

The results are being processed but they show a growing interest in precision agriculture technologies applied to the fertilization of orchards also thanks to the development of new machines and suitable techniques. Indeed, it is demonstrated that the management of spatial and temporal variability in cultivations leads to numerous advantages for the economic and environmental management of the farm.

Preliminary Design and Analysis of a Modular Autonomous Mobile Robot for Vineyard Operations

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Keywords: Modular robotics, mobile robotics, vineyard spraying, agricultural automation, winter pruning

Objectives

Robotics is affecting more and more different sectors. In particular automation of agricultural processes could bring several advantages by reducing waste and human effort, that's why several robots to perform a wide range of agricultural tasks are in development. However, the design of a multi-purpose robot for vineyard operations presents still some challenges like its hardware adaptability and compatibility. To tackle some of these challenges, this paper presents the conceptual design of a modular autonomous mobile robot for vineyard operations. The aim of this work is to provide design principles for a modular robot able to perform multiple tasks that are common for vine growers, such as green pruning, winter pruning and spraying. The main advantages of such a robot are multiple. First, it can be considered eco-friendly as it can reduce chemicals consumption, polluting emissions and soil compaction. Second, it can minimize the need for manpower, that means less repetitive tasks to be done and less exposure to chemicals. Finally, its modularity can allow to easily switch tools and to re- design some modules with little changes to other features.

Methods

For designing this system, we adopted a design thinking approach. Thus, first requirements and concepts were created and evaluated via interviews of vine growers. Second, concepts were classified upon the evaluation. And last, the winning prototype was designed with Solidworks CAD software and evaluated on its mechanical and functional properties via a FEM analysis.

Results

By using this method, we have developed an initial design for a multipurpose robot that concentrates on the drive system and the serial hybrid powertrain design, the selection of the structure, the tool design, and their incorporation with the frame, as well as an initial estimation of the mass to conduct a preliminary FEM static analysis of the frame. As a result, we have evaluated the feasibility of the concept and identified the key features of all subsystems. Therefore, this study lays the groundwork for creating a versatile and effective robot that can be used for multiple vineyard operations.

Assessment of Vegetation Indices as tool to Decision Support System for Aromatic Crops

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Keywords: DSS, multispectral imagery, aromatic plants, vegetative vigour, rosmarinus officinalis, salvia officinalis

Objectives

In the last few years, the interest of consumers towards nutraceutical and aromatic herbs recorded a growing trend, both in terms of product types and consumption. In Sicily, *Origanum vulgare* L., *Lavandula angustifolia* L., *Salvia officinalis* L., *Rosmarinus officinalis* L., *Laurus nobilis* L. and other similar aromatic plant species are used for food, flavourings, cosmetics and medicinal purposes. The aim of this work is to analyze and evaluate by means vegetation indices the vegetative vigour of the aromatic crops as tool to DSS (Decision Support System).

Methods

The study area is located in Grotte (Italy), Agrigento District. A pre-flight software was used to planning the acquisition data by means Unmanned Aerial Vehicle equipped with a multispectral camera. The high resolution multispectral images were mosaicked and thematic maps of vegetation indices (VIs) NDVI (Normalized Difference Vegetation Index), GNDVI (Green Normalized Difference Vegetation Index) and NDRE (Normalized Difference Red Edge) were generated to assess the health status of aromatic plant.

Results

The results shown that, UAVs with multispectral camera can be significantly applied to obtain data about vegetation growth, vigour and site-specific applications as tool to DSS.

POSTER PRESENTATIONS

TOPIC 8. Noise, Vibration, Dust, Endotoxin, Microorganism

Assessment of Hand-Arm Vibrations of Chainsaws for Urban Trees Maintenance

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Keywords: Work safety, urban forestry, hazardous physical agents

Objectives

Tree felling, processing, and pruning of urban trees are performed with the use of various types of manual tools or motorized chainsaws. The use of such equipment can cause the exposure of workers to hazardous physical agents, including hand-arm vibrations that can incite occupational diseases. In this work, levels of exposure to hand-arm vibrations caused by three chainsaws for pruning (two electric powered and one with an endothermic engine) and two pole chainsaws (one electric and one endothermic) were assessed.

Methods

The collection of vibration data was carried out according to the ISO 5349-1:2015 standard relating to the measurement of the levels of vibrations transmitted to the hand-arm system. The instrument chain was composed of an 8-channel signal acquisition/processor, two triaxial accelerometers and an accelerometer calibrator. The two accelerometers were positioned on the handles used during the cutting operation. The legislation provided for the orientation of the three axes according to the basic biodynamic and/or centric coordinate systems relating to the hand.

Results

Obtained results indicated that occupational exposure, calculated in terms of daily vibration exposure A(8), to hand-arm vibrations in intermediate mechanized activities, can cause health risks for workers, especially with regard the pole chainsaws. The results showed the need for actions that can minimize transmission in activities with a level above the guidelines.

Evaluation of Noise Emissions and Cutting Performance of Chainsaws for Small Scale Forestry Operations

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Keywords: Work safety, urban forestry, hazardous physical agents

Objectives

Exposure to high levels of noise over time can cause effects on operators' health. Furthermore, the use of chainsaws in urban areas during the maintenance of urban vegetation, contributes to the noise pollution of cities. This paper reports the results of tests carried out with the aim of evaluating the levels of exposure noise caused by three chainsaws for pruning (two electric powered and one with an endothermic engine) and two pole chainsaws (one electric and one endothermic).

Methods

Equipment were tested in cutting operations of fresh wood logs of hardwood and softwood of different species. The acquisition of sound pressure values was carried out according to the Italian Legislative Decree 81/08, using a certified instrumental chain including an eight-channel signal acquisition/processor, microphone capsules, and acoustic calibrators. The sound measurements were performed with the equipment in three different conditions: with the engine at idle (only for the internal combustion one), at maximum and during cutting. To evaluate the cutting performance, the cutting times were measured taking into account the diameter of the wood samples, then expressing the results in seconds cm⁻².

Results

The results showed that the tested electric chainsaws, during cutting, have comparable noise emission and cutting velocity, while obviously those of the petrol chainsaw is much higher. It was found a significant difference in the averages of the dB(A) values, considering both woods tested, between the two electric chainsaws. However, also the electric equipment showed serious levels of noise emissions that have been considered in calculating the daily exposure levels (LEX,8h).

Investigation on the Applicability of an Active Noise Control System in the Tractor Cabin Under Repeatable Workload Conditions

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Keywords: Driver's comfort, feedback control, dynamometric brake, agricultural tractor

Objectives

The research on the reduction of noise emissions in work environments was strongly improved by the active control technology aimed at reducing the noise level through sound emissions that are out-of-phase with the primary noise. Therefore, such a technology should be capable to generate a “quiet zone” around the driver's head, reducing the auditory distress, unlike the common passive techniques based on the application of sound-absorbing and sound-insulating materials to the cab's components. For these reasons, CREA-IT carried out a study on an active noise control system (ANC) inside the cab of a currently on the market medium power tractor. The study aimed at evaluating the efficiency of the ANCS in order to reduce the operator's exposure to noise and increase the level of comfort through setup improvements of its hardware and software components.

Methods

The tests to verify the efficiency of the ANCS installed in the cab of an agricultural tractor have been conducted at CREA-IT tractor's test bench. The ANCS components positioned inside tractor's cab were two reference microphones (which measured the noise level and sent the corresponding signal to the system) and two loudspeakers (which emitted the out of phase noise generated by the system). The tractor was connected to an electromagnetic dynamometric brake, used for the evaluation of tractors' performance in accordance with OECD's Code 2. The brake was used to set the engine workload conditions, allowing repeatable noise measurements along the entire working interval of the engine. The resulting sound level in the cab was measured at driver's ear level by a further microphone connected a data acquisition system, according to the ISO 1999:2013 standard, providing the continuous equivalent levels of both “linear” (L_{peq}, Te) and “A-weighted” (L_{pAeq}, Te), sound pressure, calculated in thirds of octaves between 20 Hz and 20 kHz.

Results

The ANC system presented in this study aimed at integrating the passive the conventional noise-control systems in noise reduction and increasing the driver's level of comfort and health safeguard. The noise level in the cab was measured all along the engine working range described by its characteristic curves of torque and power. This method allows to reliably compare the noise levels observed with and without the ANC system. The results indicated that the ANC system is capable of reducing the equivalent level of acoustic pressure in the entire working range of the engine, with higher effectiveness under heavy workload conditions.

POSTER PRESENTATIONS

TOPIC 10. Impacts of crops and livestock productions

Quinoa Cultivation in Italy: Some Insights in Seed Production

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Keywords: Losses, threshing, harvest management, combine setting, efficiency

Objectives

Quinoa has been used as the primary food source by ancient Andean societies for thousands of years. It is being cultivated in France, England, Sweden, Denmark, Holland and Italy (FAO, 2023). Quinoa is defined as "the Golden Grain" due to its high nutritional content. In fact, the protein content of quinoa grains is higher than other cereals while it has better distribution of essential amino acids. It contains a high amount of essential fatty acids, minerals, vitamins, dietary fibers, and carbohydrates with beneficial hypoglycemic effects while being gluten-free. The quinoa plant is resistant to cold, salt, and drought. For these reasons, production of quinoa followed an increasing trend that gained attraction in 2013, as it was proclaimed to be the international year of quinoa (FAO, 2023). Quinoa is an interesting crop characterized by the significant seed losses during harvest phase causing economic damages for the farmers. This aspect is more and more important because according to 12th goal of Agenda 2030 reducing food loss and waste can contribute to environmental sustainability by lowering production costs and increasing the efficiency of food systems. Currently, UN Member States lose 13.8 per cent after harvesting and during transport, storage and processing alone, amounting to a cost of over \$400 billion a year.

Methods

The paper aimed to estimate the technical efficiency and the environmental and economic impacts of not specific harvest technology for quinoa in Italy. The environmental impact of quinoa production was carried out using the life cycle assessment methodology (LCA) by means an attributional approach, while the economic performance was carried out applying the life cycle costing methodology (LCC). The combine used for quinoa mechanical harvester was equipped with cereal header with field loss monitoring end setting. The lost seed was collected by appropriate trays inserted between the crop rows on the ground during the harvesting. The test was conducted in field of CREA-CI Foggia (Italy).

Results

The results are interesting especially in terms of point of losses in the field and punctual setting management of the combine harvester. Interesting results are also obtained in terms of economic and environmental terms for emerging supply chains.

Beet Sowing Seed Production: Environmental and Economic Aspects in Irrigation System Some Insights

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Keywords: Industrial crops, water, energy, efficiency

Objectives

The choice of the irrigation system involves various economic and environmental aspects which determine the overall impact of the crop. Several factors are considered for the analysis: costs, crops, energy prices, raw materials, labor availability, water location, field operations, application efficiency. The energy aspect, with either internal combustion or electrical engines remains one of the most impactful elements for the environment and the crop production sustainability. The International Energy Agency stated that the energy used for water purposes (850 TWh) is about 4% of global electricity consumption plus 50 million tons of oil equal to thermal energy. In Europe, not much changes with the water sector as the main buyer with an energy expenditure equal to 3% of the total electricity consumption.

Similar irrigation systems can lead to important influences both in terms of crop production and energy required and this work aims to evaluate these aspects in the same crop.

Method

Taking a specialized crop as a reference, two irrigation types characterized by specific systems and methods of water administration are compared, examining the impact of the crop on the resulting environmental and economic aspects for the producer. The systems used were the roll-up sprinkler and the self-compensating hose, both powered by separated pumping units by diesel or electrical engine. This solutions are very common in the production areas examined. Following some authors, the study focused on the technical and economic aspects of each system; while as regards the environmental aspect of two irrigation systems, the water footprint was assessed.

Results

Very interesting results both from an environmental and an economic point of view mainly linked to the management of the water pressure, the main element impacting the energy consumption of the crop.

POSTER PRESENTATIONS

TOPIC 11. Precision farming and traceability

Long-term Impact of Soil Management on the Physical and Hydraulic Properties of a Fine-Textured Soil: Insights on the Effects of Minimum Tillage and No-Tillage for Precision Farming Applications

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Keywords: Long-term experiments, hydraulic conductivity, water retention, bimodal soils, precision farming

Objectives

The main aim of this work was to investigate the long-term impact of soil management (i.e., minimum tillage, MT and no-tillage, NT) on soil physical and hydraulic properties, for precision farming applications. Specific goals were: i) investigate the impact on saturated hydraulic conductivity (Ks) and unsaturated hydraulic conductivity (Kh), ii) analyse the soil water retention curve, WR using uni- and bi-modal models, and iii) use the experimental information to highlight the main differences between MT and NT.

Methods

The study was carried out at the experimental farm of CREA-AA (Foggia), in a long-term experiment aimed at investigating the effects of MT and NT on wheat. For each soil management, twelve sampling points were selected in the summer 2022 to determine K and WR. BEST-steady was applied to obtain a complete soil hydraulic characterization and obtain Ks. The tension infiltrometer was used to estimate Kh at the pressure head value, h that discriminates the activation of soil macropores (h=-3 cm), and the Steady-state Single Test was applied for such purpose. For each plot the WR, obtained by applying standard methods on thirty-six soil samples, was parameterized with the uni- and bi-modal version of van Genuchten model (vGum and vGbm).

Results

The geometric mean of Kh-Ks was 0.99-77.9 mm h⁻¹ (CV=23-69%) under MT and 1.04-90.3 mm h⁻¹ (CV=29-54%) under NT, resulting not statistically different between soil management according to a t-test (p=0.05). Therefore, a high hydraulic conductivity increase in soil macropores, both under MT and NT (i.e., a factor 79-87) was observed, suggesting a some bimodality of the investigated soil. The soil water retention curve was adequately parameterized regardless of the model, but vGbm returned more reliable estimates of saturated water content, θ_s . Both models returned the same θ_s estimation in 17% (MT) and 78% (NT) of considered cases. Results showed a model impact that was more evident for macroporosity, PMAC estimation rather than for air capacity (it was virtually irrelevant for plant available water capacity). When PMAC was calculated using θ_s values from different parametrization, it deviated from the identity line plotting vGbm vs vGum data in 8% and 39% of cases, respectively under NT and MT; such deviation always occurred for highest porosity values (approximately, when $\theta_s > 0.64$ cm³ cm⁻³). The pore sizes of MT that, on average, were twice higher compared to NT, further confirmed the differences between the soil management systems investigated.

Smart Hive Prototype to Improve Honey Production in Mediterranean Environment

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Keywords: Apiary, environmental condition, precision beekeeping, real time

Objectives

The aim of the study was to design a smart hive prototype, developed by the authors, to monitor the main environmental factors, both inside and outside the hive, and honey production, in real time. A preliminary on-site validation of the system in three experimental sites in Sicily is presented to achieve a tool to support beekeeper's decisions.

Methods

The Dadant Blatt type hive was used as a base for realizing the prototype, the most used in Italy; the raised bees were local crossbreeds of the *Apis mellifera* species. The developed system consisted of a series of sensors connected to a microcontroller, which acquires the data and periodically sends them to a server via modem. The sensors external to the hive were four load cells, a thermocouple which allowed the measurement of the ambient temperature, a hygrometer and a microphone. The microcontroller collected the acquired data, sending them to a cloud every 15 minutes via a multiband GSM modem.

Three study areas were selected to position the hive prototype: site A, located at the Department of Agricultural, Food and Forest Sciences of the University of Palermo; site B, located in the territory of Ventimiglia di Sicilia (province of Palermo); site C, located in the territory of Castellamare del Golfo (province of Trapani).

Results

Figure 1 shows some data acquired by the system and their arrangement through the specifically created web interface. Data are referred to the hive placed in site A, over a 6 days period. Figure 1(a) shows temperature values monitored inside the hive and Figure 1(b) shows relative humidity values inside the hive.

ER Diagram and its Applications in Fresh-Cut Fruit Chain

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Keywords: Citrus, traceability, tracking, tracing, information system, entities

Objectives

Traceability in the food chain refers to the capacity to track the movement of food products and their ingredients through all stages of production, processing, and distribution, both forwards and backwards. This involves recording and connecting the various stages of the food production, processing, and distribution chain. Traceability comprises two types of movement: tracking and tracing. Tracing involves creating a record of a product's history within the food chain, including its origin and subsequent movements. Tracking involves the ability to locate a product at any given point within the supply chain through real-time monitoring of its movements from one location to another. Traceability is then crucial for a variety of reasons, including food safety, food security, quality control, and efficient operation. The more information that is recorded, the easier and faster it becomes to identify the affected food, reduce risks to consumers, and save both time and money.

In this study the principles of traceability were applied to the citrus fruit supply chains by exploiting the Entity-Relationship (ER) diagram capabilities. After the analysis of the processes in the citrus fruit supply chains, it was deemed possible to implement a Computerized Information System that implements the traceability procedures for fresh-cut citrus fruits. The aim of the system is to manage data on the origin and history of citrus fruits, in order to trace areas, food industry and possibly further characteristics of origin of the marketed product.

Methods

An Entity Relationship (ER) Diagram is a visual tool that represents the relationships between 'entities', such as people, objects, or concepts, within a system. These diagrams are commonly used in the fields of software engineering, business information systems, education, and research to design or debug relational databases. The production of the ER diagrams includes the elaboration of a flow sheet illustrating how entities relate within a system. The methodology provides for adding attributes for entities with meaningful names in such a way that they can be easily understood. In the fresh-cut fruit chain five macro-entities (received, selected, prepared, processed, packaged) and three entities (Travel documents, Products, Providers) useful for product traceability were identified.

Results

The information required for the precise traceability of the product, within the supply chain, is identified in the lot number, always unique for each quantity delivered, from which the packaged product originates. The unique identification code, in other words the batch number, by virtue of the cascade architecture, is considered necessary and sufficient to trace the origin of the processed product. The results constitute the basis for the appropriate definition of an information system for traceability inherent to the fresh-cut citrus. The ER diagram has also been customised for the application to multiple fruit sectors through specific variations in the ID_typology_selection and ID_typology_processing sections.

POSTER PRESENTATIONS

TOPIC 13. Environment Safety, People Health Protection and Welfare

An Example of Integrated Approach for Human Biomonitoring of Exposure to Pesticides: Dose and Effect

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Keywords: Dose biomarkers, oxidative stress biomarkers, active substances, metabolites

Objectives

An integrated approach for monitoring the differences in exposure and health effects for workers performing different tasks in agriculture was tested within the project “One- health model for studying a pesticide exposure scenario: effects on human health and food quality”, funded by INAIL.

Methods

19 workers were monitored during: the last treatment on a tomato greenhouse crop before harvest, the re-entry activity 48 hours later and the harvesting after 12 days. Urine samples were collected before and after the work shift and 12 hours later. The concentration of pesticides applied on tomato (target) and also not applied (non-target) and the percentage of their metabolites relative to the maximum chromatographic peak area (Rel %) were measured in HPLC-MS/MS. Quantitative determination of four effect/oxidative stress biomarkers, namely 8-oxo-7,8-dihydroguanine, 8-oxo-7,8-dihydro-2'-deoxyguanosine, 8-oxo-7,8-dihydroguanosine and 3-nitrotyrosine, was carried out on the same samples. All results were normalized for the creatininuria.

Results

The substance most frequently found was 4-hydroxy-3-mesityl-1-oxaspiro, a metabolite of the target pesticide Spiromesifen, with percentages in re-entry and harvest activity of about 15 Rel%, higher than in treatment (1.3 Rel%). Flupyradifuron, a non-target pesticide, was found in similar concentrations for all the tasks accounting for 0.20% of the AOEL. A highly significant difference with a control group was observed for 8-oxo-7,8-dihydro-2'-deoxyguanosine (oxidized DNA guanosine) in workers performing the treatment ($p < 0.01$), and in a minor extent ($p < 0.05$) for 8-oxo-7,8-dihydroguanosine (oxidized RNA guanosine) in those performing the re-entry and harvesting tasks. These preliminary results indicate a higher exposure for re-entry and harvesting tasks than for treatment for the target pesticide Spiromesifen, and a very low and more homogeneous exposure to Flupiradifuron, not used in the tomato treatment. On the contrary, a higher level of oxidative stress in the treatment workers lead us to consider the possible different effect of working tasks on human health.

Environmental and Economic Aspects in Irrigation Systems Analyses for Industrial Crops

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Keywords: Management, technical means, water, energy, efficiency

Objectives

The choice of irrigation system involves analyzing several factors: costs, crops, energy prices, raw materials, labor availability, water location, field operations, application efficiency. The energy aspect is one of the most impactful elements for the environment and the economic sustainability of water management for irrigation. The International Energy Agency stated that the energy used for water purposes (850 TWh) is about 4% of global electricity consumption plus 50 million tons of oil equal to thermal energy. In Europe it does not change much with the water sector as the main buyer with an energy expenditure equal to 3% of the total electricity consumption. Similar irrigation systems can be involve important influences both in terms of crop production and energy and this paper aims evaluate this aspects in the same crop.

Method

Taking the production of beet sowing seed as a reference, two irrigation typologies characterized by specific systems and methods of water administration are compared, examining the resulting environmental and economic aspects. The systems used were the self-propelled sprinkler with roll-up wing powered by an endothermic motor-pump unit, a very widespread solution in various areas, and localized irrigation with self-compensating hoses, again with an endothermic supply system and adequate filtration system. The study focused on the economic aspects of each system; with a focus on their advantages and limitations; while as regards the environmental aspect of two irrigation systems, the water footprint was assessed.

Results

The first results are very interesting above all because they highlight important differences on very widespread and often superficially applied systems without distinction in horticulture and industrial crops. These results have an impact both from an environmental and an economic point of view and are often linked to the management of the water pressure in the irrigation system adopted.

Combustion Emission Profile in a Fluidized Bed Biomass Boiler

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Keywords: Biomass burning, fluidized bed plant, PM emission, abatement system

Objectives

The aim of the work is to evaluate the emission profile considering the particulate matter (PM) fraction by using a fluidized bed boiler with abatement systems, burning a biomass sample mix of woodchip and compost. This study concerns estimating the impact on air quality and the health and safety of operators and citizens, considering the presence of multi-cyclone filter and bag filter.

Methods

Biomass burning tests were carried out into a fluidized bed biomass plant (500kW) with automatic control systems (air content regulation, dosing of additives into the combustion bed and dry dedusting system). To reduce PM emissions, the plant is also equipped with the multi-cyclone filter and bag filter in series. For combustion tests was used a mix of wood chips and compost from the agroforestry and agri-food industry. For the sampling and determination of the PM fractions (PM10, PM 2.5 e PM 2.5-10) a constant flow sampler QB1 coupled to an inertial impactor prototype developed by DADOLAB Srl in compliant with ISO/CD 23210.

Results

Results about PM emission confirm that the effect of the abatements system (bag filter) is relevant, thanks to its capacity to effectively retain the PM generated. Results are better for larger fractions (PM10) than lower as PM 2.5 that represents the most dangerous fraction because being the finest it can penetrate the secondary airways and consequently can be a real danger to the health of the operators as well as to the quality of the air. This result is probably related to the nature of the biomass with high level of unburnt inside.

POSTER PRESENTATIONS

TOPIC 15. SHWA & Augmented reality, Gamification, IoT

Agricultural Application of LoRaWAN Technology

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Keywords: Digital agriculture, wireless, precision agriculture, long range, IoT

Objectives

Managing areas without network coverage to carry out environmental and soil monitoring represents a high-priority goal for developing new technological scenarios for digital agriculture. Being able to interact with remote plants and systems, such as for example environmental control systems and technical means including irrigation is now crucial for implementation with precision agriculture to advance in agriculture 4.0.

Methods

LoRaWAN technology is based on LoRa (Long Range) technology operating at low frequencies which is becoming a standard for wireless communications for the Internet of Things (IoT), as it guarantees a greater range of coverage coupled with low power consumption and low costs, being of extreme importance for specific application contexts such as agricultural ones. This standard falls within the Low-Power Wide-Area Network (LPWAN) type of network, i.e. those types of networks that have large signal coverage distances, low power consumption and are low cost. Thanks to the principles on which LoRaWAN technology is based, there are many uses that are becoming increasingly widespread in the agricultural context in several sectors, thus managing to reach areas up to now without network coverage enabling the application and exploitation of tools for precision agriculture.

Results

The CREA prototype laboratory, Open Hardware, is implementing and creating a LoRaWAN network on the national territory dedicated to agriculture, currently aimed at research, based on open-source technology, for various scientific applications, ranging from the soil, plants and the environment, up to the remote control of irrigation systems, as well as energy consumption measurements for automated stables. The success achieved by this technology opens the door to new developments that go beyond the agronomic and forestry aspect, such as real-time monitoring and traceability of agricultural vehicles, confirming the importance that this technology can offer in the agricultural scenario.

POSTER PRESENTATIONS

TOPIC 17. Food Safety

Food Safety: Sharing Knowledge of the Use of Renewable Energy in Agriculture in Myanmar

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Keywords: Safety, hygiene, physical sensors, decent work, sustainable agriculture

Objectives

The main objectives are: i) technological transfer of sustainable agro-food transformations; ii) sharing unit operations for process control; iii) sharing of simple food safety procedures; iv) preparation of processed products; v) influence of climate on the solar drying process; vi) shelf life vii) climate change, sustainable agriculture, food security, decent work. viii) gender empowerment ix) business and marketing organization.

Methods

The program financed by ILO Japan, envisaged the realization of 4 months, theoretical-practical training program in Ywangan region (Myanmar), carried through distance learning. Participants, (all young farmers, mostly women) were selected by ITALIA-BIRMANIA.INSIEME (Rome, Italy) based on previous training/education. The project involved 5 villages, with as many solar dehydration systems, for a total of 24 students.

Results

The distance-learning training program was held by CREA and ITALIA-BIRMANIA.INSIEME social and scientific experts. It was carried out on weekly basis on the Zoom platform, according a planned theoretical and practical activities. The program made it possible to update and discuss a wide range of issues related to the introduction of sustainable technologies to combat malnutrition, guarantee food security, promote sustainable tourism and decent work. The lessons aimed at young people to facilitate their entry into the labour market and entrepreneurship, thanks to the prospect of new opportunities through food transformation. The program was effective both in terms of scientific content, discussion, and practical exercises. Each lesson had a final part of evaluation based on the answers to a specially prepared questionnaire and homework.

The theoretical-practical approach has been used to produce tomato and vegetable preserves in oil and vinegar, as well as for the production of jams and marmalades and dehydrated food. The concepts of hygiene and food safety, food transformation, packaging, marketing and, above all, the basic concepts for using solar dehydration systems have been transmitted and implemented: "Food transformation through solar dryer: air humidity; thermal and hygrometric quantities".

Local factory built the solar dehydration systems workstations for the 5 villages. All the villages conducted successfully the experimental tests producing dehydrated fruit and vegetables. In the final part of the training, the participants organized themselves in production groups, created their trade logo and now they are successfully selling their products in local supermarkets. All the trials were followed remotely.

Monitoring the Microbial Load of Ready-To-Eat Rocket Salad During the Shelf-life by NIRS

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Keywords: Shelf life, rocket salad, portable nir, microbial load, modified atmospheres

Objectives

The evaluation of microbial growth during the shelf-life of ready-to-eat Rocket Salad; the ability of NIRS to calibrate the microbial load; the use of non-destructive techniques also in microbiological field; the influence of modified atmospheres on the shelf-life of ready- to-eat products.

Methods

Freshly cut rocket salad was packed in air (A) and in two modified atmospheres (B= 30% O₂, 70% N₂; C= 10% CO₂, 5% O₂, 85% N₂) in BOPP bags. Samples were examined at t = 0 and after 1, 4, 7, 11 and 13 days of refrigerated shelf-life. Headspace composition was analysed by checking CO₂ and O₂ concentrations. The microbial load was monitored by plate counts of: i) yeasts and moulds; ii) mesophilic bacteria; iii) coliforms; iv) enterobacteria; v) staphylococci; vi) psychrophilic bacteria; vii) *Listeria* spp. and viii) *E. coli*. NIR spectra were collected with a microNIR OnSite-W spectrometer (VIAVI Srl, Italy) in reflectance mode, over the range 900–1600 nm (50 scans; 125 reading points). After applying appropriate spectral chemometric pre-treatments, regressions between microbiological and spectral data were computed by partial least square (PLS) regression.

Results

The monitoring of the headspace composition evidenced changes due to the physiological respiratory activity of plant tissue: CO₂ amount increased, except for C sample, and O₂ decreased throughout shelf life. The atmosphere (C) with reduced O₂ confirmed the ability to control the aerobic microbial growth. Pathogen bacteria (*Listeria* and *E. coli*) were not detected in all products, assuring the product safety. PLS regression models predicted the microbial load (log₁₀ CFU/g) of non-pathogenic bacteria with R² higher than 0.76 and low errors in cross-validation.

These preliminary results suggested the suitability of NIRS as sustainable technique also in microbiological field, reducing cost and time of analysis.

Effects of Sewage Sludge Soil Amendment on Paddy: Multi-Parameter Monitoring of Plant Stress

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Keywords: Impact on crops, safety, supply chain, environment, rice

Objectives

The distribution of organic materials, such as semi-solid residue deriving from wastewater purification, represents a valid possibility of applying circular economy strategies with the concrete objective of closing the production cycle. The distribution of sewage sludge to crops can be a nutritional input for plants but, like any input administered to a phase of a food cycle, it must be observed for the impacts it might have on plants, humans and the environment. Traceability technologies, as well as those relating to Block-chain, require the possibility of bringing the evaluation of the observed aspects back to numbers, for the purpose of digitization and, therefore, to an easier contribution in the flow of information from production to the consumer.

Methods

Experimental activities were carried out in a rice field located in Basiglio (MI, Italy), where the effect of two sewage sludge distributions (25 and 34 t/ha) was monitored. The experiment aimed to evaluate the effects of sewage sludge distribution on plant physiology and odor emission. The physiological performance of rice plants was studied by measuring the chlorophyll content, acquiring NIR spectra (900-1670 nm) and analyzing the spectroscopic indices obtained from satellite data (i.e. NDVI, MCARI, TCI, Chlred-edge), highly correlated with the chlorophylls content. GC-MS analysis was carried out on sludge samples suspended in water and extracted with the SPME technique, using a three-phase fiber (DVB-CAR-PDMS).

Results

Total chlorophylls content increased by +15% in plants treated with the highest concentration of sewage sludge, suggesting its positive effect on rice crop, whereas no differences were observed in plants treated with the lowest concentration. PCA model built with NIR spectra allowed a separation between control and treated samples based on the sewage sludge concentration. The two treatments did not show statistically significant differences in any of the measured spectral indices. As expected, a positive correlation was found between NDVI, MCARI and TCI, while the Chlred-edge index showed a negative but significant correlation. Moreover, the absence of negative variation of the above-mentioned vegetative indices suggested that at these doses, the sewage sludge distribution did not reduce plant health status. The characterization of the volatile compounds profile of sewage sludge suggests that the choice of appropriate mechanical operations may be effective in reducing olfactory nuisances.

Monitoring Fresh-Cut Fruit Status by an Arduino-Based Datalogger

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Keywords: Fruit, temperature, quality, sensors, monitoring system, simulations

Objectives

Commercial success of fresh-cut (“IV range”) products is due to several factors, including the factory monitoring at the various stages of the production process and the high quality, in terms of both appearance and organoleptic and nutritional characteristics, which are generally associated with this type of product. From a regulatory point of view, the inter-ministerial circular of January 25, 2016, no. 637 - Implementing provisions concerning fresh-cut fruit and vegetable products, refers to Ministerial Decree 3746 of 20/06/2014, whose art. 3 establishes that the finished product leaving the processing plants for the distribution phase must have a temperature below 8 °C, while art. 6 specifies that “food sector operators must ensure that at every stage of distribution, fresh-cut fruit and vegetable products are kept at a temperature below 8 °C”. Therefore, the main parameter to be considered to ensure the quality of the product is the temperature. Continuous monitoring of temperature at all stages of the production and distribution process thus becomes a necessity to ensure the quality of fresh-cut products and avoid the onset of conditions that may represent a risk for consumers.

Methods

In order to investigate a low-cost sensor system able to perform the required monitoring task, a system built around an Arduino Uno R3 board was carried out. The board is based on an 8-bit AVR RISC microcontroller with 32 kB of flash program memory and 2 kB of SRAM and different peripherals, such as timers, ADC, SPI bus interface, I2C bus interface and so on. A Pressure-Temperature-Humidity sensor BME280 was added to this board, together with an RTC (Real Time Clock) DS3231 and an SD card interface. The sensor is interfaced to the Arduino board by means of the available I2C bus. The DS3231 RTC has also an I2C bus interface and it has its own timekeeping 3 V coin battery. The SD card interface is a simple connector that is able to contact the SD. This external memory is interfaced to the Arduino board by means of the SPI bus interface. The system is powered up using a 9 V battery. Each time the system is powered up, a log file is created in CSV format on the SD card and the sensors data are read every 1 minute. Each row in the log file has a timestamp and the sensor data values, comma separated allowing easy post processing. This prototype has been used to monitor different critical events that can occur during standard transportation and storage phases of the target goods. For this purpose, a set of simulation protocols have been defined.

Results

Use of the device allowed measuring the temperature variation recorded during the simulation of different conditions such as proper operation of the refrigeration system, malfunction of the refrigeration system, mismanagement during the loading and unloading of the goods, and temporary failure of the system during the shutdown of the engine of the transport vehicle.