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“Safety Health Welfare in Agriculture Agro – food and Forestry Systems”



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TOPIC 1

“WMSDs”

ORAL PRESENTATION

Agricultural Ergonomics Research and Outreach in California

Fathallah F.A.

University of California, Department of Biological and Agricultural Engineering

One Shields Ave, Davis, CA 95616, USA

Tel +15307521612, Fax +5307522640, fathallah@ucdavis.edu

The main aim of this paper is to give an overview of agricultural ergonomics research and outreach activities in California. Another aim is to introduce the California AgrAbility Program.

A discussion about research publications on agricultural ergonomics is presented. In most countries, agriculture is recognized as one of the most hazardous industries, with musculoskeletal disorders (MSDs) being at the top of problems facing workers in labor-intensive agriculture. This talk gives an overview of the extent of MSDs in California agriculture, and a historical perspective on how ergonomics has been used to reduce the health effects of labor-intensive agriculture in California. The California AgrAbility Program is introduced and its main mission highlighted.

A summary of exposure to MSD physical risk factors within various classes of California crops is given. There are various administrative and engineering controls for abating MSDs in agriculture. These range from programmed rest breaks to mechanized or partially-mechanized operations. Worker-based approaches such as prone carts and platforms, and load transfer devices hold promise in combating the prevalent stooped work in agriculture. Although physical risk factors are major contributors to MSDs in agriculture, other psychosocial, organizational, cultural, and socio-economic factors could be important contributors to the development and prevention of these disorders. These factors may play a central role in the effective implementation and adoption of any intervention approach. Despite the advent progress in new technologies in agricultural practices, reliance on labor will always be a major cornerstone of agriculture for at least the foreseen future. An overview is given on how AgrAbility Programs in California and other US states have been assisting disable farmers and farm workers find solutions and other assistive technologies to maintain an active and productive work in agriculture.

Keywords: MSDs, Ergonomics, AgrAbility, Labor-Intensive Agriculture.

OWAS and REBA for the assessment of WMSDs in motor manual tree felling. Which is the best approach?

Gallo R., Mazzetto F.

*FUB, Free University of Bolzano, Universitätsplatz 5, 39100 Bolzano, Italy, 0471017623,
raimondo.gallo@unibz.it.*

The risk to run into a Work-Related Musculoskeletal Disorder (WMSD) is very high when operating in the primary sector. As a matter of fact the number of professional illnesses related to the WMSD in Italy is high.

The study was carried out in the Autonomous Province of Bolzano (northeast of Italy), it consisted in the assessment of operator's postures during felling operations, through the assignment of a WMSD's index of exposure. This assessment was carried out with two different procedures: REBA and OWAS. A comparison of the results obtained from the two assessment tools was performed. In order to perform the assessment, every felling operation has been recorded with a digital camera, and it has been divided into three subtasks: pre-cutting operations, cutting operations and post-cutting operations. For each of them a frame capture every 10 second has been analysed.

The assessment of the OWAS and REBA's score shows that the OWAS standard has a general tendency to assign a lower index to exposure in comparison to REBA. This is evident both for subtask operations and for the whole felling operation. Moreover, OWAS, due to its easier technique for the assessment has shown a greater capability to assess body posture also in not clear situation because the operator was partially hide by a tree or far from the camera.

In conclusion, from this study it is possible to determine that OWAS assessment is able to perform a faster and more precise and sensitive assessment than REBA.

Keywords: Body Posture Assessment, Forestry, Chainsaw, Cutting Operations.

TOPIC 1

“WMSDs”

POSTER PRESENTATION

Study of posture during plowing operations. Analysis of the pressures to the seat.

Romano E., Cutini M., Bisaglia C.

Agriculture Research Council – Agricultural Engineering Research Unit (CRA-ING); Laboratory of Treviglio, via Milano 43, 24047 Treviglio BG, ITALY.

Tel 0039 0957147518, Fax 0039 0957147600, elio.romano@entecra.it

With reference to the suspension system, the seats on the market are at the moment basically divided into three groups: mechanical, pneumatic suspended and active/semiactive seats. Since the end of the '60 studies on operator comfort to the tractor showed that the operation of the suspension of the seat is influenced not only by the design of the same, but also by the posture and dynamic behaviour of the driver. Many studies have been developed on the characterization of the stresses for the operator evaluating vibrations in different conditions, in agreement with the European Directives for the approval of seats. Interviews were conducted in the industry, which showed limb disorders whose cause could be related to the pressure against the seat.

It will be studied the interaction between the body and the seat of two operators recording the pressure values of 31 points in which were placed pressure sensors having a diameter of 100 mm². The recording of the data will be during the operations of plowing a field previously planted with corn. It will be recorded the pressure values in the two directions of plowing, alternately with the right and left wheel within the groove.

Processing of the data will allow the evaluation of the effect of stress on the seat to the two operators during plowing operations. Through geostatistical analysis will be realized a map could shows the barometric distribution of peaks. These maps could suggest the critical areas in which the body of the operator is affected by the higher stresses. The preparation of such maps, suggesting the critical areas in which the body undergoes the greatest stresses, can be a step for integration to the reading of the vibrations in the objective evaluation of the comfort of the seat.

Keywords: Comfort, Barometric maps, Agricultural tractor.

A review of recent studies on the risk assessment from repetitive movements in agriculture

Schillaci G.⁽¹⁾, Camillieri D.⁽¹⁾, Rapisarda V.⁽²⁾, Failla S.⁽¹⁾, Caruso L.⁽¹⁾, Romano E.⁽³⁾

⁽¹⁾ *University of Catania. Di3A, Mechanics and Mechanization Section*

Via Santa Sofia, 100 – 95123 Catania, ITALY.

Tel 0039 0957147512, Fax 0039 0957147600, Email: giampaolo.schillaci@unict.it

⁽²⁾ *Università di Catania. Medicina del Lavoro.*

Via Santa Sofia, 78 – 95123 Catania, Tel/Fax 0039 0953782366,

Email: nandorapisarda@libero.it

⁽³⁾ *Agriculture Research Council – Agricultural Engineering Research Unit (CRA-ING);*

Laboratory of Treviglio, via Milano 43, 24047 Treviglio BG, ITALY.

Tel/Fax 0039 0363 49603, Email: elio.romano@entecra.it

Abstract

Some studies carried out from the AA. in the last years and concerning Work related Musculoskeletal Disorders (WMSDs) in agriculture come are presented.

The studies involve viticulture, tomato growing, nurseries in greenhouses, She – ass milking. In particular, some of them are related to the frequency concerning manual operations, the strength concerning the various part of the hand measured by instrumented scissors specifically assembled.

Results show that for the assessment of the risk should be considered throughout the annual cycle. Instrumented scissors allow to recognize the strength exerted on different parts of the hand. The strength intensity reported by the instrument was correlated to the strength evaluation coming from a group of people and when necessary it can be converted in the Borg CR10 scale normally used for these kind of researches. Physicians could now utilize the measured strength intensity exerted in different parts of the hand with the aim to foresee the development of disabilities involving workers' arm and hand. Results obtained from surveys on vine cutting frequency suggest that the daily curve that represents the cuts per min has to be identify correctly, otherwise the risk could be wrongly evaluated. Obtained results highlight how is important a multi-disciplinary approach, putting together the competences coming from agricultural mechanization (that includes work organization), ergonomics and occupational medicine.

TOPIC 2

“Machine Milking, Animal Welfare, Sustainable Livestock”

ORAL PRESENTATION

Ergonomic issues and musculoskeletal disorders among ewe dairy workers involved in mechanical milking

Murgia L.⁽¹⁾, Rosecrance J.⁽²⁾, Maieli P.⁽¹⁾

⁽¹⁾*University of Sassari. Dept. AGRARIA, Viale Italia, 39 – 07100 Sassari, ITALY, Tel +39 079229284, Fax +39 079229285, Lelia Murgia<dit_mecc@uniss.it>*

⁽²⁾*Colorado State University. College of Veterinary Medicine and Biomedical Sciences
1681 Campus Delivery, Fort Collins, CO 80523*

In comparison to the traditional practice of hand milking, the use of mechanical milking equipment has considerably improved worker comfort and work efficiency of milking operations on sheep farms. Nearly 50% of Italian dairy sheep are located on the island of Sardinia, where 3.2 million head are raised on approximately 12,700 farms. Over the past 20 years, the industrialization of sheep husbandry has led to a marked increase in average herd size per farm (from 121 to 250 head) and to a large increase in milking mechanization.

Milking operations are mainly performed in parlor milking systems (82% of farms, average 275 head/farm), while bucket and trolley systems are used in small herds with less than 190 head. The parlor design is usually parallel based on a single or double stanchion row mounted along a milking pit where the worker operates. As an alternative, the stalls can be assembled on an elevated platform, either static or movable, thus enabling the worker to operate at the same level of the parlor. Among the low milkline systems, the parlor type with 24 stalls and 12 milking units (2 stalls/unit) is the most common configuration, while the type with 24 stalls and 6 milking units (4 stalls/unit) is the prevalent choice in high milkline installations. Considering the short milk emission period of the Sardinian ewe, one operator can usually manage about 6-8 milking units without incurring the risk of udder overmilking.

Although mechanization has reduced the physical load imposed on the workers, some studies have reported an association between the cow milking tasks and symptoms of musculoskeletal disorders (MSD) in the upper extremities and back (Nevala-Puranen et al., 1996; Stal et al. 2001; Doupbrate et al., 2009; Kolstrup et al. 2012). Several studies suggest that MSD risk factors are mainly associated to the physical work environment in relation to the worker's anthropometrics (Stal et al. 2003; Jakob et al. 2012; Cokburn et al., 2015). Most of the scientific literature refers to dairy cow milking operations, while only limited information is available on ergonomics of sheep milking parlor systems (Pazzona, 1985; Billon, 2005; Berger 2001). The purpose of our study was to investigate the ergonomic design of ewe milking parlors and the prevalence of MSD symptoms among ewe dairy workers.

Manually Milking Ewes and the Risk of Carpal Tunnel Syndrome

Rosecrance J. ⁽¹⁾ and Murgia L. ⁽²⁾

⁽¹⁾ *Colorado State University. College of Veterinary Medicine and Biomedical Sciences 1681
Campus Delivery. Fort Collins. CO 80523 USA*

Phone: 970-491-1405, john.rosecrancde@colostate.edu

⁽²⁾ *University of Sassari. Dept. AGRARIA
Viale Italia. 39 – 07100 Sassari. ITALY*

The region of Sardinia, Italy is known internationally for the production of cheeses made from ewe's milk. Although most developed countries utilize automated milking equipment in ewe and cow dairies, the ancient task of manual milking is still performed in some countries and geographical locations (Kouyoumdjian and Machado de Araujo, 2006; Kutluhan et al., 2009). In Sardinia, Italy, manual milking of ewes is still performed on approximately 50% of ewe dairy farms. Both economic and cultural constraints have limited the adoption of modern dairy equipment by Sardinian ewe farmers. Automated milking equipment has been installed in 5,800 of the nearly 12,800 Sardinian ewe dairies. However, it is estimated that only 5,000 of the milking machines are currently in use. The under utilization of automated milking equipment is primarily due the raise in milk production costs, which has driven the smaller farms to reduce energy and material expenditures. Additionally, ewe farmers have had to increase their flock size to stay competitive. Larger flocks result in longer periods of manual (hand) milking (Figures 1 & 2). Manual milking is a task that has been characterized as “a natural model for occupational carpal tunnel syndrome (CTS)” (Kouyoumdjian and Machado de Araujo, 2006). The purpose of this descriptive study was to evaluate the prevalence of CTS among Italian ewe farmers that manually milk sheep and compare them to a sample of cow dairy farmers that use mechanical milking equipment.

TOPIC 3

“Instrumentation, Equipment, Periodic Procedures and Tests”

POSTER PRESENTATION

A laboratory test bench to analyse nozzle sprays

Cerruto E., Manetto G., Failla S., Longo D., Caruso L., Schillaci G.
University of Catania. Di3A, Section of Mechanics and Mechanization
Via Santa Sofia, 100 – 95123 Catania, ITALY.
Tel 0039 0957147514, Fax 0039 0957147600, ecerruto@unict.it

Aim of this study is to propose a low cost laboratory test bench, suitably designed to analyse nozzle sprays according to the procedure described in ISO 5682-1. It consists of a transportable trolley carrying a tank, a two diaphragms pump driven by an electric motor, and a spray boom carrying one multiple nozzle holder. The spray boom may move, under the control of a DC motor, along two slides placed above the working plane of the trolley. Acceleration and deceleration ramps may be imposed by the speed controller. According to the procedure described in ISO 5682-1, the test liquid is sprayed above Petri dishes placed on the working plane and containing silicon oil: analysing the images of the drops captured inside the oil, it is possible to measure the spray drop diameters and then all the spray features. The image acquisition system is under development.

Moreover, the test bench will be used to correlate spray features to water sensitive paper (WSP) images. Spraying at the same time Petri dishes and WSPs, the image of drops inside Petri dishes will be correlated to images on WSPs, so allowing the calculation of unitary deposits from WSP.

Finally, the tests bench will be used to experimentally validate a model describing the WSP behaviour when sprayed with drops of assigned drop size distribution and volume median diameter. In this paper WSP images were produced by simulation, assuming some simplifying hypotheses: spherical drops and circular stains randomly placed on the images. Three types of spray were simulated (Fine, Medium and Coarse) with two drop size distributions (log-normal and Rosin-Rammler). The simulations showed that the unitary deposit can be derived from the measured percentage of covered surface on the WSP images, but the knowledge of the volume median diameter of the drops is necessary, independently of the probability distribution function of drop size.

Keywords: Pesticide Application, Image Analysis, Drop Pulverisation.

Evaluation of pump-over thermal effect during red grapes fermentation: preliminary results

Guerrini L., Angeloni G., Corsini S., Parenti A.

Dipartimento di Gestione dei Sistemi Agrari, Alimentari e Forestali, Università degli Studi di Firenze. Piazzale delle Cascine, 16, 50144, Firenze, Italy, phone +39 0552755932, lorenzo.guerrini@unifi.it

In oenology, pump-over is a mechanical technique used to enhance the fermentative maceration. Pump-overs are conducted, with or without air contact, by taking the must from the bottom of the fermentation tank, and using it to spray the cap. The aim of this practice is the enhancing the phenolic and volatile compounds extraction from grape skins. Consequently, wine quality is improved in this way.

During some temperature monitoring tests a “secondary” effect of pump-over has been highlighted. Temperature affects volatile and phenolic compounds concentration too. Particularly, low temperatures may be used to improve volatile production by yeasts during fermentation, and regulate the extraction of polyphenols compounds from the solid to the liquid phase.

The aim of the work is to describe the thermal effect of pump-overs with and without air contact during a red fermentation.

Tests have been performed during the September 2014 Tenuta Argentiera (Bolgheri (LI), Italy) in a tank of 20 m³ capacity. Six probes were placed into the fermentation tank, for temperature monitoring in different zones during pump-overs.

Both kinds of pump-overs produce two main effects during fermentation: a temperature homogenization, reducing the differences among the zones of the tank, and a cooling effect, reducing the average temperature of the must. Hence, in addition to their effect on compounds extraction, pump-overs could be useful to reduce and control the temperature during red fermentation.

Keywords: Quality, Temperature, Wine.

Hose reel vs dripline irrigation systems: which is better from Carbon Footprint standpoint?

Guiso A., Ghinassi G., Spugnoli P.

Dipartimento di Gestione dei Sistemi Agrari, Ambientali e Forestali. Università degli Studi di Firenze, Italy. P.le delle Cascine, 15 - 50144 Firenze, phone, 0552755930, paolo.spugnoli@unifi.it

Irrigation plays an essential role in the cultivation of crops but it also has a relevant contribution to the environmental impact of agriculture. The present work analyzes the Life Cycle of hose reel and dripline irrigation systems, with the aim of evaluating and comparing their carbon footprint. LC analysis was carried out using the software Simapro, with the support of the Ecoinvent Database. Although water consumption is the main indicator used to assess efficiency of irrigation, it is not sufficient to evaluate its overall sustainability. Indeed the use of irrigation equipment and machines cause a large amount of GHG. The GHG of the irrigation systems have been assessed by analyzing two stages of their life cycle: production and use phases. Production phase encompasses all the impacts due to the machine industrial manufacturing from raw material extraction and processing, to production and assembly of the various components. Use phase considers the impact due to energy consumption for water distribution to the field. The functional unit is the m³ of water distributed under average technical and climatic conditions of central and northern Italy. Results show that dripline systems give rise to the highest GWP. Their high impact is due to their short lifetime, since they have to be replaced annually. On the other side, the lifetime of the travelling rain gun span for over 15 years and therefore their production impact has a lower contribution able to compensate the higher impact of the use phase due the high water working pressures.

Keywords: Irrigation, Carbon Footprint, LCA.

An olive pruning machine for marginal areas

Porceddu P.R., Canale A., Spitella S.

University of Perugia, Dept. of Civil and Environmental Engineering

Borgo XX Giugno 74 - 06121 Perugia, ITALY

Tel 0039 0755856079, Fax 0039 0755856440, pierriccardo.porceddu@unipg.it

In many sub-Apennine areas of central Italy, climatic and soil difficulties caused the spread of the olive trees more than other crops, thanks to their ability to adapt to those conditions and thanks to the help of dry stone walls.

In this way in the past was possible to have many olive lands, today in those lands there are marginal olive groves. In fact in such areas, the maintenance of olive groves is expensive and difficult, especially regarding the practice of pruning. In the absence of such pruning, olive trees would return to being new woodland. Pruning also requires workers with specific skills to maintain the right shape of trees. Such labor is increasingly unavailable.

Due to the large gradients, which make difficult and dangerous the machines use, subject to instability and tipping, with consequent risks for the operator, the mechanization is not able to improve the situation totally. In fact in many areas olive groves are neglected, resulting no gains for the farms and also lack of those areas maintenance. It is also necessary to consider the known environmental hazards related.

The aim of the research is to assemble a new machine with pruning bar provided with rotary discs, and totally operated by a remote control. The driver is placed on the ground some meters far from the machine to reduce the risk to his life, in the case of the machine rolling over.

To evaluate the efficiency of the machine some pruning tests will be done in marginal areas.

Keywords: Pruning Machine, Steep Ground, Remote Control.

TOPIC 4

“Noise, Vibration, Dust, Endotoxin, Microorganism”

ORAL PRESENTATION

Field and static tests to assess the drift of abrasion dust of dressed maize seeds

Biocca M.^{(1)*}, Fanigliulo R.⁽¹⁾, Gallo P.⁽¹⁾, Pulcini P.⁽²⁾, Pochi D.⁽¹⁾

⁽¹⁾ *CRA-ING, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Unità di ricerca per l'ingegneria agraria - via della Pascolare 16, 00016 Monterotondo, ITALY.*

Tel 0039 0690675232, Fax 0039 0690625591

Email corresponding author: marcello.biocca@entecra.it

⁽²⁾ *CRA-PAV, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Centro di ricerca per la patologia vegetale - via C.G. Bertero 56, 00156 Rome, ITALY.*

Pneumatic precision drills employed in maize (*Zea mays* L.) sowing are responsible for the emission in the atmosphere of abrasion dust containing active ingredient (a.i). In recent years, several insecticides (especially neonicotinoids) employed for maize seed dressing have been claimed to cause mortality and sub-lethal effects to honey bee (*Apis mellifera* L.). Moreover, the emitted particulate matter can be inhaled by the operators during the seed loading and manipulation and during the sowing. This work aims at assessing the amounts of a.i. emitted by precision drills during sowing operations. We carried out static tests, simulating the sowing at fixed point, and real sowings in field. To collect a.i. residues, we used passive samplers (Petri dishes) for the residues at ground level. We employed maize seeds treated with three neonicotinoids insecticides (clothianidin, imidacloprid and thiamethoxam) and with fipronil. The results show the amounts of dust emitted by a pneumatic precision drill during the sowing of maize. Moreover, a method to predict the theoretical dust drift in the field, starting from the results of the static test, is provided.

Keywords: Pesticides, Airborne Particulate, Neonicotinoids, Honey Bee, Seed Coating.

Whole-Body Vibration exposure.

An ergonomic evaluation of the effects of an active suspended cab fitted on an agricultural telehandler.

Caffaro F.⁽¹⁾, Preti C.⁽¹⁾, Micheletti Cremasco M.⁽²⁾, Cavallo S.⁽²⁾, Cavallo E.⁽²⁾

⁽¹⁾*Institute for Agricultural and Earthmoving Machines (IMAMOTER), National Research Council of Italy (CNR), StradadelleCacce, 73 – 10135 Torino, Italy; Tel. +39 0113977 Fax +39 0113489218; f.caffaro@ima.to.cnr.it, c.preti@ima.to.cnr.it, e.cavallo@ima.to.cnr.it*

⁽²⁾*Department of Life Sciences and Systems Biology, University of Torino, Via Accademia Albertina, 13 – 10123 Torino, Italy; Tel: +39 0116704617 Fax: +39 0116704508, m.micheletti@unito.it*

Exposure to whole body vibration (WBV) is one of the most important risk factors for musculoskeletal disorders (MSDs). Agricultural machinery operators are particularly at risk and it is therefore important to minimize the transmission of harmful vibrations to the driver as much as possible. Telescopic handlers are self-propelled vehicles very versatile used on different terrains and for different operations. Despite their diffusion few studies investigated their vibrational safety and comfort. The objective of the study was to investigate whether an active cab suspension system fitted on a telehandler was effective in reducing WBV and in improving comfort. Sixteen male healthy professional operators drove a telehandler on a 100m ISO 5008 smooth track at two different speeds (5 and 12 kph) with activated and deactivated cab suspension system. Adopting an ergonomic approach, different aspects of the human-machine interaction were analyzed: 1) WBV measurements, 2) subjective ratings of general comfort and local body discomfort, and 3) anthropometric characteristics of the users. The suspension system was effective in reducing WBV and in improving comfort, especially for individuals with higher stature, body mass and Body Mass Index (BMI). Some neck/shoulder and lumbar complaints seem to remain, even when the system was activated. Results suggest that the operators, given their wide range of physical variability, may need more adjustable or customizable WBV reduction systems.

Keywords: Ergonomics, Comfort, WBV, Telehandler, ISO 5008.

A filtering-recycling device to reduce dust drift from pneumatic drills

Pochi D.⁽¹⁾, Biocca M.^{(1)*}, Fanigliulo R.⁽¹⁾, Gallo P.⁽¹⁾, Pulcini P.⁽²⁾, Perrino C.⁽³⁾, Marcovecchio F.⁽³⁾

⁽¹⁾ *CRA-ING, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Unità di ricerca per l'ingegneria agraria - via della Pascolare 16, 00016 Monterotondo, ITALY.*

Tel 0039 0690675232, Fax 0039 0690625591, marcello.biocca@entecra.it

⁽²⁾ *CRA-PAV, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Centro di ricerca per la patologia vegetale - via C.G. Bertero 56, 00156 Rome, ITALY.*

⁽³⁾ *CNR-IIA, Institute for Atmospheric Pollution Research, Consiglio Nazionale delle Ricerche, Via Salaria, Km 29.300, Monterotondo St., Rome, 00015, ITALY.*

The utilization of dressed seed is a widespread practice to control pests and diseases with reduced doses of pesticides. In recent years, some insecticides employed in seed dressing (namely neonicotinoids and fipronil), have been claimed to contribute to honeybees (*Apis mellifera* L.) spring mortality and decline. Pneumatic precision drills used in maize (*Zea mays* L.) sowing can release amounts of dust coming from the abrasion of dressed seed. To reduce dust spread, we developed an effective prototype device for pneumatic drills, which uses partial recirculation and filtration of the air by means of an anti-pollen filter and an electrostatic filter. Tests at fixed point (simulating sowing of maize seed treated with imidacloprid, thiamethoxam, clothianidin and fipronil) were carried out to assess the efficiency of prototype. Measurements were carried out by sampling, with different methods, the air emitted by the drill in different configurations. With the application of the prototype having the double filtration (anti-pollen plus electrostatic filters), gravimetric and chemical analyses of samples showed values of reduction of emissions always greater than 90%, both in terms of the total mass dust and of the a.i. The application of the electrostatic filter to the system resulted particularly efficient in the reduction of the smaller particles (up 4 µm of diameter). The contribution to the reduction of the sole recirculation system was around 70%. This study contributed to the description of abrasion dust in terms of particle size distribution and provided elements which are useful to further development of the prototype.

Keywords: Neonicotinoids, Honeybee, Seed Coating, Particulate, Aerosol, Pesticides.

Model to analyse semi-active suspension system for a tractor cab

Varani M., Mattetti M., Molari G.

Department of Food and Agricultural Sciences –University of Bologna, viale G. Fanin 50, 40127, Bologna, Italy, tel. +39 051 2096193, fax +39 051 2096178, massimiliano.varani@unibo.it

Tractor driving causes comfort and spinal problems due to low-frequency vibrations. For these reasons suspension systems have been adopted in order to limit the vibration transmitted to the driver. However, it has been shown that despite the use of traditional devices like suspensions on the axles, on the cab and on the seat, the level of vibration in some operations is higher than the vibration level limit prescribed by the Directive 2002/44 /CE. The vibration may be reduced through semi-active cab suspension system. The purpose of this research is to develop a specific control system for tractor cab semi-active suspensions in order to reduce the level of vibration compared to traditional suspensions. The analysis of the results shows that the designed control produced a reduction in the level of vibrations transmitted to the driver and an increase in the driving comfort.

Keywords: Ride Vibration, Agricultural Machinery, Controlled System.

TOPIC 4

"Noise, Vibration, Dust, Endotoxin, Microorganism"

POSTER PRESENTATION

Development of an app for using a smartphone as vibro-meter for effects on health evaluation

Cutini M., Bisaglia C.

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CRA)

Unità di Ricerca per l'Ingegneria Agraria (CRA-ING), Laboratorio di Treviglio

Via Milano, 43 – 24047Treviglio (BG), ITALY. Tel 0039 036349603, Fax 0039 036349603, maurizio.cutini@entecra.it

Italian statistics on work safety are pointing out an increasing number of reports about professional diseases. In this frame are considered the whole-body vibrations (WBV) that could affect operators driving agricultural tractors. The common approach to prevent the related pathologies is to measure some situation that could be representative of the task or to refer to existing database with similar tractor and use. This research follows the approach of monitoring in real time and providing for the development during the working day the driver's level of exposure with a vibro-meter developed as an app to be used with a common smartphone.

This application respects the filters and the weights reported on the ISO 2631:1997; the smartphone has an orientation to respect and gives on the three axis the real time data of exposure (the last minute), the daily exposure (referred to 8 eight hours of work) and the time of exposure. The application has been tested on an agricultural tractor in different operative conditions.

The application provides a simple method for an initial assessment of whole body vibration level of exposure. The system can't substitute a certified chain of measurement but could represent a low-cost device for operator's training for practically explaining the question of the dose of vibration and the importance of monitoring the daily, cumulative dose of vibration.

Keywords: Tractor, Safety, Whole Body Vibration, Early Warning.

Noise, vibration and dust emissions of a forestry chipper

Fornaciari L., Fanigliulo R., Sperandio G., Biocca M. Grilli R., Gallo P., Pochi D.

CRA-ING, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Unità di ricerca per l'ingegneria agraria, Via della Pascolare, 16 - 00015 Monterotondo (Rome), ITALY. Tel 0039 0690675215, Fax 0039 0690625591, marcello.biocca@entecra.it

Wood biomass is an important energy source, which is attracting much interest from research and agro-industry. Before energy conversion, wood biomass is generally processed into particles of variable size and shape. This treatment is called chipping and it is performed by chippers. Chipping operations generate much noise, vibration and inhalable dust, which can cause potential health risks for the operators. We tested a chipper (Farmi CH260) with loader feeding for chipping of wood material until 260 mm of diameter, powered by a four wheel driven tractor. The tests of chipping were conducted on seven years old poplar trees. The noise and vibration levels were measured in accordance with the ISO 1999:2013 and the ISO 2631-1:2014 standards. The amount of inhalable dust, during field operations, was evaluated according to UNI EN 481:1994. In line with the requests of the Italian law no. 81/2008 and the measured values of noise and dust emitted and vibration transmitted, we calculated the personal daily exposition to noise, vibration and inhalable dust levels, in terms of $L_{EX,8h}$, $A(8)$ and $mg\ m^{-3}$, respectively, with the aim to evaluate the most risky parameters of the wood chipping operations.

Keywords: Wood Comminution, Operator Seat, Poplar, Whole-Body Vibrations, Exposure Time, Health Protection.

Laboratory vibration measurement from hand-held harvesters for olives

Manetto G., Cerruto E., Schillaci G.

University of Catania. Di3A, Section of Mechanics and Mechanization

Via Santa Sofia, 100 – 95123 Catania, ITALY.

Tel 0039 0957147515, Fax 0039 0957147600, gmanetto@unict.it

Vibration represents the most important risk connected with the use of portable harvesters for olive and other drupe. This research was developed within an inter-laboratory test (Round Robin Test – RRT) with the purpose of measuring the vibration to the hand-arm system produced by one portable harvester. To standardise the measurement under load conditions, a suitable laboratory test bench was used. This paper reports the results obtained by the Section of Mechanic and Mechanisation of the Di3A.

The results showed an average acceleration of 2.6 m s^{-2} in idling running and of 13.6 m s^{-2} under load conditions. The highest component was always along x direction (12.8 m s^{-2} under load), the lowest in y direction (1.8 m s^{-2} under load). The test bench proved to be a useful tool to standardise the test conditions, but further studies are necessary to compare acceleration values measured with the test bench and during harvesting.

Keywords: Safety, Olive Harvesting, Vibration Exposure, Hand-Arm System.

Dust emissions with a new hazelnut mechanical harvesting prototype

Pagano M.⁽¹⁾, Biocca M.⁽¹⁾, Cecchini M.⁽²⁾, Colantoni A.⁽²⁾, Fanigliulo R.⁽¹⁾, Sperandio G.⁽¹⁾, Fedrizzi M.⁽¹⁾, Gallo P.⁽¹⁾, Guerrieri M.⁽¹⁾, Pochi D.⁽¹⁾

⁽¹⁾*CRA-ING, Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria, Unità di ricerca per l'ingegneria agraria, Via della Pascolare, 16 - 00015 Monterotondo (Rome), ITALY.*

Tel 0039 0690675215, Fax 0039 0690625591, marcello.biocca@entecra.it

⁽²⁾*Università degli studi della Tuscia, Dip. DAFNE - Via S. Camillo De Lellis, 01100 Viterbo ITALY.*

The mechanical harvesting of hazelnuts (*Corylus avellana* L.) can show a potential health risk because machinery raise soil particles and dust that can be inhaled by the operators. The paper points out the possibility of reducing the quantity of respirable dust emitted into the atmosphere during the harvesting operations by the use of a prototype pick-up harvesting device, mounted on a self-propelled vacuum machine. The tests were carried out in September 2014, to determine the amount of dust emitted into the atmosphere during the hazelnut harvesting. The tests compared the performance of the machine with the novel device mounted and the same model of the vacuum harvesting machine equipped with the conventional harvesting system (consisting of two counter-rotating brushes with rubber blades). A portable particle laser spectrometer and a personal air sampler with a membrane filter were employed to measure the respirable particulate. In average, a lower concentration of dust was recorded near the operator who drives the harvesting machine, with some differences depending on the employed system (spectrometer or air sampler) to assess the dust concentration. The reduction of dust emission is likely due to the configurations of the novel device, which can contain the dust emitted during the harvesting. Further research will be conducted including the determination of the level of free crystalline silica (SLC), another risk factor for the health of operators.

Keywords: Health, Comfort, Particulate Matter, *Corylus avellana* L., Harvesting.

Risk of exposure to fluoro-edenite fibers of agricultural workers operating in Biancavilla's territory

Rapisarda V.⁽¹⁾, Ledda C.⁽¹⁾, Giampaolo Schillaci⁽²⁾.

⁽¹⁾ *Department of Clinical and Experimental Medicine, Section of Occupational Medicine, University of Catania, Via Santa Sofia, 87-95123, Catania, Italy.*

⁽²⁾ *University of Catania. Di3A, Section of Mechanics and Mechanization, Via Santa Sofia, 100 – 95123 Catania, ITALY.*

The municipality of Biancavilla lies 515 m above sea level on the SW slope of the Etna volcano in Sicily, Italy. It extends for about 70 km² from Mt Etna to the river Simeto and the town occupies a twentieth of its territory. The economy of the city is mainly based on agricultural, sheep and cattle breeding and meat and dairy products.

A significantly increased standardised rate of mortality from pleural mesothelioma recorded among its inhabitants is comparable to that reported in asbestos-exposed cohorts (Di Paola et al., 1996). This mortality rate has been attributed to exposure to a fibrous amphibole identified by Gianfagna and Oberti (2001) as fluoro-edenite (FE), chemically similar to tremolite except that its OH groups are replaced by fluorine. FE fibres have been found in inert materials, such as sand and rubble, extracted from a stone quarry excavated inside the Mt Calvario, lying on the immediate outskirts SE of the town. This material has been widely used for about 50 years for local building (Comba et al., 2003; Paoletti et al., 2000; Rapisarda et al., 2003).

FE has been recently classified by the IARC as carcinogenic to humans (Grosse et al., 2014).

In a previous study we identified a high risk of pleural plaques in building workers occupationally exposed to FE (Rapisarda et al., 2015).

In the present study, in order to assess the concentration and diffusion of airborne FE fibres in the farmland around the municipal territory, we have used a previously validated sheep model (Rapisarda et al., 2005), as a biological indicator of fibre pollution. In this way it is possible to assess the risk of exposure to FE fibers run by agricultural workers.

Noise risk assessment in a modern oil mill plant

Vallone M., Febo P., Catania P.

University of Palermo. Department of Agricultural and Forest Sciences, Viale Delle Scienze Edificio 4 – 90128 Palermo Tel +39 91 23865609, mariangela.vallone@unipa.it

High levels of noise usually occur in the oil mill plant because of the machines used to extract extra virgin olive oil. In Italy the Law Decree 81/2008 defined the requirements for assessing and managing noise risk, identifying a number of procedures to be adopted at different noise levels to limit workers exposure. This study aims at evaluating the equivalent and peak noise level inside a modern oil mill plant area. Twenty measurement points were identified inside the oil mill plant area where the machines for olive oil extraction are located (about 200 m²). The instrument used for the measurements was a precision integrating portable sound level meter, class 1, model HD2110L by Delta OHM, Italy. The measured sound levels exceeded the limits allowed by the regulations in all the measurement points inside the working area; values exceeding the threshold limit of 80 dB(A) were recorded coming up to a maximum value of 93.3 dB(A) close to the hammer crusher. The operators involved are obliged to wear the appropriate Personal Protective Equipment.

Keywords: Noise Risk, Oil Mill Plant, Threshold Limit.

TOPIC 5

“Occupational Health”

ORAL PRESENTATION

Safe in the field: a project for training and integration of foreign agricultural workers

Cecchini M.⁽¹⁾, Monarca D.⁽¹⁾, Colantoni A.⁽¹⁾, Baciotti B.⁽¹⁾, Bedini L.⁽¹⁾, Menghini G.⁽¹⁾, Porceddu P.R.⁽²⁾

⁽¹⁾ *University of Tuscia. DAFNE, Via San Camillo De Lellis, snc-01100 Viterbo, ITALY.*

⁽²⁾ *University of Perugia. DICA, Borgo XX Giugno, 74 - 06121 Perugia, ITALY.*

Tel 0039 0761357357,cecchini@unitus.it

The project "Safe in the Field", funded by the Lazio Region and activated by Department of Science and Technology for Agriculture, Forestry, Nature and Energy and "Innovation & Resources" Ltd, was launched September 15, 2014 and ended March 14, 2015.

The first phase of the project was a research regarding the training needs for workers in the farms of Lazio Region. Subsequently training courses were provided, each lasting 10 hours, per groups of workers from different nations (Italy, India, Romania), with the presence of native tutors in the classroom and the availability of educational materials in language.

One of the aims of the research is to understand the relationship between risk perception among farmers and the main risk factors to which they are exposed. Furthermore to investigate the influence of the training in risk perception in agriculture.

The research regarding the training needs for workers was done by means of a study on distribution of different crops in the region, a study on injuries and occupational diseases in agriculture (Lazio) and a questionnaire submitted to a sample of farms.

As it regards the research on risk perception, the data collection was made possible thanks to the use of a questionnaire designed to investigate the perception of risk that was given to a sample of 99 agricultural workers at the beginning and at the end of the courses.

The results of the project consist in training of agricultural workers. A product of the project was the site <http://ergolab.wix.com/sicurincampo> that provides a platform for the support of teaching materials for work health and safety training for farmers (training materials in 5 languages).

A previous research from the same Authors showed that the perception of risk is related to having attended training courses, but those who report having attended safety courses do not always enact safe behavior.

While we cannot draw conclusions about the behavior of workers after attending the course, the analysis of the questionnaires shows a clear improvement in the perception of risk.

Keywords: Training and Information, Foreign Workers, Safety and Health.

Injuries for female workers in agriculture – An initial study on causes and preventive measures

Geng Q. and Lindahl C.

JTI – Swedish Institute of Agricultural and Environmental Engineering, Box 7033, SE-750 07 Uppsala, Sweden. Tel 0046 10 5166927, Fax 0046018300956, qiuqing.geng@jti.se

The aim of this paper was to contribute to the future prevention of women's occupational injuries in agriculture via identifying the main causes and circumstances related to these injuries.

The study included analyses of existing data of occupational injuries during a five year period (2009-2013) suffered by women working in agriculture in Sweden. The injury data consisted of compensated work injury claims from the AFA Insurance and work injuries reported to the Swedish Work Environment Authority. Descriptions of the specific events of about 600 injury claims and reports were studied thoroughly in order to gain a deeper understanding of the causes and circumstances. The data regarding, for instance, the source of injury, age, time of year, type of production, injury characteristics and other factors, were analysed. Based on the statistical output, the causes and possible preventive measures were discussed with a reference group consisting of people with extensive practical experience in the area of agriculture work environment.

Preliminary findings indicated that the majority of injuries were animal-related (~55 % of the injuries), with cattle as the most commonly involved animal followed by horses. Cases associated with sorting/moving cattle, leading horse and milking tasks represented high proportions of the injuries. Working with livestock were subjects to the injury in 64 % of the cases, and younger women (<25 years) seemed to be overrepresented in the statistics. The injuries occurred more frequently in the months of September and December.

The further analysis of the injuries should be carried out as a case study together with the suffered persons in the field to gain more detailed information of the underlying causes and suggest more specific measures. The focused areas of preventive measures were also discussed.

Keywords: Prevention, Risk, Work-Related Injury, Statistics, Animal.

Psychosocial condition and mental health of Swedish farmers and rural entrepreneurs

Kolstrup C.L.

Swedish University of Agricultural Sciences (SLU)

Department of Work Science, Business Economics & Environmental Psychology (AEM)

PO Box 88, SE-230 53 ALNARP. Phone: +46 40 41 54 94, christina.kolstrup@slu.se

The expansion of small family farms often implies increased financial responsibility, risk taking, employer responsibility and long working hours. Agriculture represents a profession whose success is highly dependent on uncontrollable external conditions such as weather, legislation, disease outbreak, environmental changes and negative societal attitudes. Moreover, farmers' face normative and market pressures and are expected to maintain high production standards, a stable economy and to act in socially conscious and environmentally responsible ways. The combination of uncontrollable external factors, increased expectations and weak social support may cause poor psychosocial working conditions and ultimately a decreased mental health.

The objective of this study was to examine the psychosocial working conditions and mental health of farmers' operating small size Swedish farms with different production sectors such as crop, dairy, beef and pig.

The study was conducted in 2010-2011 among 470 farmers comprising 177 crop farmers, 139 dairy and beef farmers and 154 pig farmers. The General Nordic Questionnaire for Psychological and Social Factors at Work (QPSNordic) was administered to assess subjective perceptions of the psychosocial work conditions and mental health.

The three groups reported general well-being regarding their psychosocial work conditions and health, however, dairy and beef farmers perceived their psychosocial work conditions and mental health as worse compared to crop and pig farmers. This was characterized by higher work demand, more negative impact regarding work and leisure time, less contentment concerning how the dairy and beef farmers dealt with the physical and psychosocial work demands, worse general health and more exhaustion after a work day. The participants were asked about the extent to which they felt stressed by various external factors. The external factors that especially crop farmers and dairy and beef farmers experienced as most stressful was the EU legislation, comprehensive subsidy regulations, lots of governmental and EU-related controls and delayed payments, and the Swedish authorities' attitude towards farmers. Increased demands on environmental issues, from society and consumers, weather conditions, animal welfare legislation, varying market prices, increased crime in rural areas, agro-terrorism, disease outbreaks among plants and animals and concerns for the future of the farm were other external factors that were stressful for the farmers. Based on the results, an action plan for improvement of the psychosocial working conditions, mental health, and social support in rural areas should be the next step to be developed.

Sustainable health and safety of Ugandan farmers

Kolstrup C.L.

Swedish University of Agricultural Sciences (SLU)

Department of Work Science, Business Economics & Environmental Psychology (AEM)

PO Box 88, SE-230 53 ALNARP. Phone: +46 40 41 54 94, christina.kolstrup@slu.se

‘Sustainable agriculture’ and food security requires ‘sustainable health’ and safe working conditions for farmers and farm families. Farmers in good health will be able to provide for their families and contribute to the local farm community. There is limited or almost non-existing research available regarding health and safety of farmers in Africa and data is essential to understand and change patterns of human health and safety. In Uganda, these issues are not considered from an agricultural aspect although the majority of risk factors regarding human health and safety are related to agriculture.

The objective of the study was to interview Ugandan farmers and family members regarding their attitudes towards health, safety and risk factors in an agricultural context, and how it affected their daily lives and livelihood.

The study was conducted in Uganda May 2014 and comprised interviews with seven male and female farmers, and transects walks on each farm.

In general the level of knowledge and awareness of agricultural health and safety risks, disease and injury prevention among the farmers was low. The farmers claimed few agricultural related complaints, injuries or diseases. It was obvious from the farmers’ responses that health and safety concerns (e.g. diarrhea, cough, fever), cuts while using the machete in the plantation, bruises when handling the animals and symptoms of poisoning from using insecticides on the

animals were nothing worth talking about and considered as part of the occupational hazard. The most important topic mentioned by the farmers was the use of chemicals and drugs related to livestock. Once a week the farmers sprayed the animals with an insecticide to prevent ticks, lice, tsetse flies and other biting nuisance flies using a back or hand sprayer. The spraying was conducted without personal protection equipment (PPE) which was considered too expensive and difficult to obtain. The farmers explained that they usually felt unwell, dizzy, vomited, and had pain and burning feeling in the face and eyes after spraying. Sometimes the symptoms were so severe that they needed treatment and bought medication without prescription at the local drugstore where the storekeeper often had limited or non-existing knowledge about the chemicals or drugs, except for dosage.

The availability of agricultural health and safety training in the region was non-existing and the farmers expressed the need for information and practical training in agricultural health and safety, disease and injury prevention.

Health and Safety Challenges among Dairy Workers in the United States

Menger, L. M., Stallones, L., Pezzuti, F., Roman Muniz, N., & Rosecrance, J.

Department of Psychology Sage Hall MS 1879

Colorado State University, Fort Collins, Colorado 80523-1879 USA

Phone: 001-970-491-6156, Fax: 001-970-491-1032, lorann.stallones@colostate.edu

Dairy farming is among the most dangerous agricultural settings. The purpose of this study was to describe the work experiences of dairy workers in the United States (U.S.) to design appropriate safety training programs. The long-term goal of the work is to eliminate occupational injuries among a vulnerable (primarily Latino) workforce in industrialized dairy operations.

Focus groups were conducted before or after work shifts. Workers were asked to describe their work experience at the dairy, quality of relationships with their coworkers and manager/s, as well as safety policies and procedures, and training experiences. Focus groups were conducted in Spanish and required approximately one-hour. Discussions were recorded, transcribed and translated into English, and analyzed for themes. Forty-four dairy workers participated.

The workers described their jobs as highly stressful, characterized by strenuous manual labor and time pressures. Participants reported many equipment issues and environmental hazards on the dairy, including exposure to unsafe conditions and numerous harmful substances. Relationships with coworkers were generally described as positive and team-oriented, while relationships with managers were more varied and negative. Participants reported limited knowledge regarding safety policies and procedures and made numerous suggestions for how to improve safety training.

The participants identified individual, organizational and environmental points of intervention that can be used to inform management and training programs in order to promote and maintain a higher level of safety within the U.S. dairy industry.

Keywords: Occupational Health, Dairy Workers, United States.

Community Engagement in the Prevention of Injuries and Deaths from Agricultural All-Terrain Vehicle Use

Rosecrance, J., Lagerstrom, E., Gilkey D.

Colorado State University. College of Veterinary Medicine and Biomedical Sciences 1681 Campus Delivery. Fort Collins. CO 80523 USA Phone: 970-491-1405, john.rosecrance@colostate.edu

All-Terrain Vehicles (ATVs) have become an essential aspect of efficient agricultural work but have led to many injuries and deaths. Since 1982 over 12,000 people have been killed in the United States riding ATVs for occupational and recreational uses (CPSC, 2014). ATVs are used in farm and ranch operations with increasing popularity resulting in 65% of all occupational related deaths occurring in the agricultural sector (Helmkamp et al., 2012). Occupational use of ATVs (Figure 1) is on the rise in many sectors because of their versatility, adaptability and affordability but has led to a nearly 200% increase in work-related fatalities reported in the U.S. between 1999 and 2008 (Helmkamp, 2011).

TOPIC 5

“Occupational Health”

POSTER PRESENTATION

Evaluation of safety aspects on a machine for nuts harvesting

Camillieri D.⁽¹⁾, Caruso L.⁽¹⁾, Cecchini M.⁽²⁾, Colantoni A.⁽²⁾, Cutini M.⁽³⁾, Monarca D.⁽²⁾, Romano E.⁽³⁾, Schillaci G.⁽¹⁾

- (1) *University of Catania. Di3A, Section of Mechanics and Mechanization, Via Santa Sofia, 100 – 95123 Catania, ITALY. Tel 0039 0957147514, Fax 0039 0957147600, lcaruso@unict.it*
- (2) *Department of science and technology for Agriculture, Forest, Nature and Energy, University of Tuscia, via San Camillo de Lellis snc – 01100 Viterbo (Italy)*
- (3) *Agriculture Research Council – Agricultural Engineering Research Unit (CRA-ING); Laboratory of Treviglio, via Milano 43, 24047 Treviglio BG, ITALY. Tel e Fax 0039 036349603*

The great part of the machine on the market for the collection of the nuts is characterized by a suction member placed over a cart with wheels or tracks, pulled by a tractor. This solution, although effective and efficient in rational cultivation with planting distances designed specifically to allow the passage of agricultural vehicles, misses instead possibility of use in spontaneous mountain hazel, without a regular planting distance. Moreover, the steep slopes that usually occur in wild hazel, make impractical the manoeuvres with the possibility of overturning the tractor vehicle and the carried truck.

Recently were born, also in the traditional way, simple mechanical solutions which consist in placing the suction member for harvesting, above small self-propelled trucks. Recent research has been conducted to evaluate the safety of the operations of harvesting of nuts in sloping land related aspects in noise and roll-over.

In this study was evaluated, in addition to efficiency and to working hours, safety aspects of a machine made by a local craftsman, but that has a commercial success in the Etna area, of considerable importance for the Hazelnuts in Sicily and for the Nebrodi park. The machine is characterized by a vacuum system placed on a self-propelled crawler to collect the nuts in sloping land and with soils corrected with very close terraces and not easy to reach for the traditional mechanization. In particular, attention was focused to aspects of noise level and to stability, evaluated by a tiltable platform.

Moreover will be assessed the principle health risks due to biomechanical overload (Work related Skeletal Muscle Disorders), will be analysed through the indices risk assessment of increased use, with particular regard to the operators involved in the harvesting and the manual handling of the product.

Data analysis and evaluation of safety aspects will identify the machine's ability to meet the harvesting operations and any limitations in terms of safety.

Keywords: Safety, Harvesting, Nuts.

Influence of training, procedural and organizational measures in the reduction of the risk due to manual handling of loads

Cecchini M., Riccioni S., Bedini R., Cossio F., Monarca D., Colantoni A., Delfanti L.M.P., Longo L.

University of Tuscia.DAFNE, Via San Camillo De Lellis, snc-01100 Viterbo, ITALY.

Tel 0039 0761357357, cecchini@unitus.it

The link between the musculo skeletal disorders (especially those affecting the bones, nerves, joints, muscles, tendons and blood vessels) and manual handling of loads, is nowadays worldwide recognized. This risk is present in many production sectors, but in some activities more than others, including agriculture (INAIL), risk indexes are often above the warning thresholds.

The research evaluated 20 agricultural and agro-livestock Lazio's farms, using a methodology proposed by EPM Research Unit (Milano, Italy) in compliance with criteria laid down by Annex XXXIII of the Italian Legislative Decree n. 81/2008 (transposition of several European Directives including 90/269/EEC about manual handling of loads).

This research also studied appropriate ways to make a quantification of the efficiency and effectiveness made by the procedural and organizational redesign proposal, presenting concretely and economically feasible measures, useful in the short term.

Keywords: Niosh, Risk Analysis, Prevention, Safety and Health.

A population-based comparison of injuries among farm and non-farm adults in Alberta, 1999-2010: A retrospective cohort.

El Kurdi S., Gao H., Drul C., Svenson L., Yiannakoulis, N., Voaklander D.

Injury Prevention Centre, University of Alberta, 4075 RTF - 8308 114 St NW, Edmonton, AB T6G 2E1, Canada. Tel: 780.492.6019, Fax: 780.492.7154, don.voaklander@ualberta.ca

Agriculture is considered as one of the most hazardous occupations with the 4th highest mortality rates by industry in Canada. The purpose of this study was to examine the rates and risks of (1) all-cause and (2) agricultural injury across adult farm and non-farm populations in Alberta.

We conducted a population-based retrospective cohort study utilizing data from multiple administrative health databases. Crude injury rates were calculated and proportional-hazards regression with a counting process was applied to obtain hazard ratios for injury adjusting age and sex.

We identified a total of 220,911 adults who experienced 947,247 injuries. Rural Non-Farmers experienced the highest death rates at 74/100,000 person-years, followed by the Farm Rural study group at 58, the Urban group at 52.1 person-years and the Farm Urban group at 48.1. All cohorts had higher hazards of all-cause injury when compared to the urban cohort after adjusting for age, and sex (Rural Non-Farm Hazard Ratio (HR)=1.09, 95% CI 1.07-1.10; Farm Urban HR=1.09, 95% CI 1.07-1.10; Farm Rural HR=1.08, 95% CI 1.07-1.09). Farmers experienced 87.5% of all agricultural injuries, with the HR= 4.68 (95% CI 4.39 – 4.99) for Farm Rural and HR= 2.87 (95% CI 2.66 -3.11) for Farm Urban when compared to the Rural Non-Farmers and adjusted for age and sex.

This study identified that injury incidence rates, severity and intent varied among urban, farm and rural cohorts. These observations suggest that intervention initiatives, with specific population and mechanism targets, are needed to tackle the challenges of injury prevention in different rural populations.

Keywords: Agriculture, Injury, Health Data, Death

Assistive Technology Database for Farmers and Agricultural Workers with Physical Disabilities

Field W. E., Jones P., Racz C.

Agricultural & Biological Engineering Department

Purdue University

West Lafayette, IN, USA

Purdue University manages the largest known database of assistive technology appropriate for safely enhancing the independence and productivity of farmers and agricultural workers with physical disabilities. The poster will explain the organization structure of the database (www.agrability.org), the contents and how it is used internationally by rehabilitation professionals working with farmers. Data on visits to the site and the most commonly used components will be presented.

Key components of the website relate to both commercially available devices and locally fabricated devices that have been designed to increase the independence of those engaged in production agriculture. The database currently includes over 1,100 items. Additional resources include technical articles on a wide range of barriers faced by persons with disabilities.

Users of the site represent over 20 countries and include primarily rehabilitation professionals and farmers with disabilities. Approximately 5,000 unique visits are made to the site each month.

A survey on occupational injuries in tree climbing in Italy

Mazzocchi F⁽¹⁾., Cecchini M.⁽¹⁾, Monarca D.⁽¹⁾, Colantoni A.⁽¹⁾, Porceddu P.R.⁽²⁾

⁽¹⁾*University of Tuscia.DAFNE, Via San Camillo De Lellis, snc– 01100 Viterbo, ITALY.*

⁽²⁾*University of Perugia. DICA*

Borgo XX Giugno, 74 - 06121 Perugia, ITALY. Tel 0039 0761357357,mazzocchi@unitus.it

The aim of this work is to know how many injuries occur to tree climber arborists, during their pruning and felling work on tall trees, both to know what kind of accidents and the reason why them happens. This study was made by means of "INFORMO", an INAIL's database which contains a list of serious and fatal injuries occurred from 2002 to 2012 counted by INAIL's Prevention Service. From such list Authors extracted only accidents related to operators who was working on tall trees, at least 2 meters above a stable ground, without using lifting platform. In these case operators would have to use ropes and harness. The result of the study consists in understanding common triggers of injuries, knowing if there are technical problems that can be solved, or other problems that can be addressed to decrease the number of accidents and their severity.

Keywords: Arboriculture, Work at Height, Safety and Health.

A Certificate Course for the Agricultural Safety & Health Profession

Murphy D, Donham K, Rautiainen R, Sheridan, C
Penn State University
221 Agricultural Engineering Building
University Park, PA 16802, djm13@psu.edu

In 1996 a Certificate Course in Agricultural Medicine was designed by a multidisciplinary consensus group in the U.S., primarily for health care providers. This course has expanded to 9 states in the U.S., Australia, and Turkey. A similar course for agricultural safety and health professionals has not existed. The objectives of the Agricultural Safety and Health Certificate Course were to: 1) Identify subject matter appropriate as core knowledge for practicing agricultural safety and health professionals; 2) Develop learning objectives for the core subject matter; and 3) Offer a pilot Agricultural Safety and Health Certificate Course.

TOPIC 6

“Environment Safety, People Health Protection and Welfare”

ORAL PRESENTATION

Italian Potential Biogas and Biomethane Production from OFMSW

Comparetti A., Febo P., Greco C., Orlando S.

Università degli Studi di Palermo, Dipartimento Scienze Agrarie e Forestali, Viale delle Scienze, Building 4 - 90128 Palermo, ITALY, Tel. +39 091 23897057, Fax +39 091 484035, carlo.greco@unipa.it

This work is aimed at predicting the potential biogas and biomethane production, using the Organic Fraction of Municipal Solid Waste (OFMSW), in Italy, where 1388 Anaerobic Digestion (AD) plants (power of 7.4 TWh, equal to 640.4 ktep) are nowadays available.

In order to compute the potential biogas and biomethane production in the 20 Italian regions, the data about OFMSW production in 2010-2013 period have been evaluated.

The Italian production of OFMSW, that was 5.2 million tons in 2013 (18% of MSW), could be used inside bioreactors for producing biogas and digestate, that must be aerobically composted into a biofertiliser. In 2013, the Italian potential biogas production from OFMSW was 739 million m³, that is equal to 444 million m³ of biomethane. The highest biogas production from OFMSW was in Lombardy region (143 million m³), having a potential biomethane production of 86 million m³. The highest OFMSW production per inhabitant was in Emilia-Romagna region (142 kg). Yet, if OFMSW was 37% of MSW, the potential biogas and biomethane production should be increased: the biomethane production increase would be 486 million m³, of which the maximum would be in Sicily region.

The biogas produced can be used for generating heat and electricity or upgraded into biomethane, distributed at dedicated stations and useful as biofuel for powering means of transport. This biofuel would replace natural gas, and, therefore, allow a reduction of GreenHouse Gas emissions of 200 g of CO₂ kWh⁻¹ (5.5 times lower) and the import of fossil fuels from abroad.

Keywords: Organic Waste, Anaerobic Digestion, Biofuels, Biofertilisers, GreenHouse Gas Emissions.

Summary of U.S. Agricultural Confined Space-Related Injuries and Fatalities and Comparable International Findings

Field W. E., Issa S., Cheng Y. H.

Purdue University

Dept of Agricultural & Biological Engineering

225 S University Street

West Lafayette, IN 47907-2093, USA. Phone: 765-494-1191, Fax: 765-496-1356,

field@purdue.edu

Purdue University's Agricultural Safety and Health Program has been documenting injuries and fatalities associated with agricultural confined spaces for over 30 years. To date, nearly 1,800 U.S. incidents/cases have been documented and findings entered into a database. In addition, cases outside the U.S. have been documented, but not included in summary data reported to date. Findings from the U.S. cases have been summarized and reported on an annual basis for the past decade. These findings have been used to promote enhanced safety measures designed to reduce the severity and frequency of agricultural confined space-related incidents.

This presentation summarizes all documented incidents including those identified outside the U.S. It is believed, based upon the frequency of non-U.S. incidents, that the problem of worker injuries and fatalities while working inside agricultural confined spaces is an international safety issue. This is especially true for incidents involving the transport, storage, and processing of agricultural grains.

Findings regarding causative factors such as type of grain and structure, worker characteristics, and the role of out-of-condition grain on increased risk of entrapment will be presented. Recommended preventative measures will be discussed.

Keywords: Grain Entrapment, Agricultural Confined Spaces, Grain Engulfment, Toxic Environments.

Determination of bystander exposure to pesticide spray drift: methodology proposal

Grella M., Marucco P., Balsari P.

University of Torino. DiSAFA, Department of Agricultural, Forest and Food Sciences.

Largo Paolo Braccini 2 - 10095 Grugliasco (TO), ITALY.

Tel. +39.011.6708610, Fax: +39.011.6708591, marco.grella@unito.it

The potential spray drift exposure of bystander and residents from orchard pesticide applications is likely to be higher than from boom sprayers, especially in Italy where the close interconnection between urban and rural areas amplify this phenomenon. On request of European Commission the European Food Safety Authority (EFSA) established a working group (WoG) for revising all available data and procedures to perform the operator, worker, resident and bystander pesticide risk assessment (EFSA, 2014). For orchard crops and vines, the most used dataset is Lloyd et al. (1987). The WoG recommended that further data shall be produced to refine the proposed assessment. Besides having limited data available at present there is no standardized method for collecting data on resident and bystander pesticide contamination. The aim of this work was to assess the efficiency of different collectors types and the different test layouts, in order to evaluate the better solution for detecting the pesticide exposure of bystanders during plant protection product (PPP) application and to propose a test methodology that may be combined with the existing ISO22866 standard methodology for arable crop pesticide drift measurement. The proposed methodology has been applied in field experiments undertaken in 2013 and 2014 measuring spray drift deposits on mannequins (coveralls and synthetic filter clothes collectors) and airborne spray drift (Petri dishes, vertical polythene line collectors). The results obtained have underlined a lacking relationship between different type of collectors, underlining the need of an appropriate experimental framework able to define the most suitable collectors type and layout to be used.

Keywords: Pesticide Bystander Exposure, Airborne Spray Drift, Collector Types, Test Methodology.

A survey on work safety in 103 agricultural farms in Friuli Venezia Giulia

Gubiani R., Cividino S.R.S., Dell’Antonia D., Pergher G.

University of Udine. DISA, Department of Agricultural and Environmental Sciences

Via delle Scienze 206– 33100 Udine, ITALY.

Tel 0039 0432558656, Fax 0039 0432558603, rino.gubiani@uniud.it

The objective of this study was to investigate current levels of work safety in agriculture, based on interviews conducted in a composite sample of 103 farms located in the region Friuli Venezia Giulia (North-East of Italy). The survey has outlined a number of patterns that were consistently found across all types of farms and only slightly varied depending on farm size, type of production and location. The results were used to define guidelines for safety experts on the field with new, updated approaches for risk assessment and accident prevention in the farms.

A U.S. Approach Towards Safety Education for Youth in Agriculture

Jepsen S. D.⁽¹⁾, Murphy D.J.⁽²⁾, Hill D.⁽²⁾, Pate M.⁽³⁾, Lawver R.⁽³⁾, Mann A.⁽¹⁾, Mann K.⁽¹⁾

⁽¹⁾*The Ohio State University, 590 Woody Hayes Dr., Columbus, OH 43210 USA*

Phone (614)292-6008; fax (614)292-9448, jepsen.4@osu.edu, mann.309@osu.edu; mann.167@osu.edu

⁽²⁾*Pennsylvania State University, 221 Agr Eng Building, University Park, PA 16802 USA*

Phone (814)865-7157; fax (814)863-1031, djm13@engr.psu.edu; deh27@engr.psu.edu

⁽³⁾*Utah State University, 2300 Old Main Hill, Logan, UT 84322 USA*

Phone (435)797-3508; fax (435)797-4002, michael.pate@usu.edu; rebecca.lawver@usu.edu

In 1968, the U.S. Department of Labor (DOL) initiated the Hazardous Occupations Order for Agriculture allowing youth employment on farms/ranches at the age of 16; students aged 14-15 years could also be employed provided they participated in a mandated tractor/machinery safety program. In the 47 years since legislation, serious deficiencies and variations occurred in the type/quality of training and the overall process for certifying young workers. While a considerable amount of effort and funding was given to update the training, no real changes have occurred. More recently, the DOL attempted to place stricter controls on youth employment and was met with much opposition from the rural community and their agricultural lobbyist organizations. With politics aside, the more important topic was how to safely involve youth in agriculture. The overall objective of this national project was to develop a sustainable and accessible clearinghouse of safety and health curricula for youth workers. A group of dedicated stakeholders received funding by the U.S. National Institute of Food and Agriculture to coordinate a national approach for youth safety education. This plan involved interactions, collaborations, and partnerships from a variety of public and private institutions. The ultimate result was to provide appropriate training to the youth workforce that increased their awareness for hazards and improved safe practices. Along the way, there was a need to build capacity within the system for teacher education and access to quality curriculum, including testing tools that met a national education standard. Likewise, enhancing public perception of legislation was needed before any success could be attained. This paper addresses the steps taken by the national project, and three results attained thus far: 1) a national symposium for stakeholders' input, 2) a national clearinghouse for curricula, and 3) training for school students in a supervised agricultural experience.

Keywords: Young Workers, Training, Public Policy.

Risks linked to the management of pressured hydrogen within a photovoltaic-electrolyzer-fuel cell power system located on a rural land

Pascuzzi S., Blanco I., Anifantis A. S., Scarascia Mugnozza G.

“Aldo Moro” University of Bari. Dept. of Agro-environmental Sciences

Via Amendola, 165/A – 70125 Bari, ITALY. Tel 0039 0805442214, simone.pascuzzi@agr.uniba.it

A power system formed by photovoltaic panels, alkaline electrolyzer and fuel cell stacks was designed and realized to supply the heating system of an experimental greenhouse. The barometric alkaline electrolyzer produces pressured hydrogen (3 MPa), which is stored inside iron tanks. The aim of this paper is to emphasize the main safety aspects of the power system connected to the management of the pressured hydrogen. From the safety point of view the electrolyzer unit has been equipped with devices able to highlight the malfunctions before they cause damages to the operators and break off the process of hydrogen production. The system can be reactivated after the repair just if the cause of malfunctioning has been removed effectively. Nevertheless the management of the products of the electrolysis process involves forethought and trained operators. Starting from the study of international directives and through the Hazard and Operability (HAZOP) Study method, the standards of safety systems for the hydrogen equipment located on a rural land have been estimated.

Keywords: Hydrogen Hazards Assessment, Water Electrolysis, Rural Lands, Risks Analysis.

TOPIC 6

“Environment Safety, People Health Protection and Welfare”

POSTER PRESENTATION

Analysis of the braking performance of counterbalanced forklift truck at varying of the tread wear

Cutini M., Brambilla M., Bisaglia C.

Consiglio per la ricerca in agricoltura e l'analisi dell'economia agraria (CRA)
Unità di Ricerca per l'Ingegneria Agraria (CRA-ING), Laboratorio di Treviglio
Via Milano, 43 – 24047Treviglio (BG), ITALY.
Tel 0039 036349603, Fax 0039 036349603, maurizio.cutini@entecra.it

The market provides tires for counterbalance forklift trucks with different kinds and depths of tread: the level of tire wear opens issues about the related safety level, in particular during braking. This research aims at verifying the effect of rubber solid tire wear on counterbalance forklift truck braking performance to verify braking performance compliance with regulations as well as standard requirements.

One counterbalance forklift truck was equipped with three different sets of rubber tires characterized by different wear levels provided that within the legal limits (new, wear, almost completely wear) evaluating its braking performance according to ISO 6292/2009 standard. Experimental activity was carried out driving the counterbalance forklift truck in two ballast conditions on three different kinds of surfaces: dry asphalt (according to ISO 6292/2009), wet asphalt and one low friction flooded surface. Different loads were applied on the brake pedal to evaluate the related braking behaviors (stopping distance and deceleration). Acquired data underwent statistical processing by means of Minitab 17.0 statistical package.

According to preliminary investigations, the kind of surface and the ballast the counterbalance forklift truck is subjected to, turn out to be the factors significantly affecting the braking performance while tire wear level does not seem to have a significant role. Further studies are nevertheless required to deepen the knowledge about the interaction between tire wear level and surface/ballast.

Keywords: Safety, Slick Rubber Tire, Wheel Locking.

TOPIC 7

“ROPS”

ORAL PRESENTATION

ROPS Design and Testing for Rigid and Foldable Structures

Ayers P. and Khorsandi F.

Department of Biosystems Engineering and Soil Science. 2506 E.J. Chapman Drive University of Tennessee, Knoxville, TN 37996. Tel: (865) 974-4942, Fax: (865) 974-4514, ayers@utk.edu

While Roll-over Protective Structures (ROPS) are prevalent on agricultural tractors in the United States, an estimated 1.6 million tractors are still not equipped with ROPS. Many of these tractors do not have ROPS commercially available although they were originally designed to support a ROPS. To meet this need, a computer-based ROPS design program was developed to quickly develop ROPS designs based on tractor weights and dimensions. The final product from the program is the ROPS design drawings with specifications that can be used to construct the ROPS. The constructed ROPS would then need to be tested to assure it meet the appropriate ROPS standard. Two ROPS designed with the program successfully passed the SAE J2194 static longitudinal, transverse and vertical tests. Many ROPS being sold on new tractors use a foldable ROPS design. These ROPS are effective when the ROPS is raised and locked in place. But raising and lowering ROPS is a tedious and strenuous task, and many times ROPS are left down during tractor operations. Fatality reports are showing that operators are dying when tractor upsets are occurring with the mounted ROPS folded down. In one study the fatalities from tractor overturns with foldable ROPS down were 50% of the total tractor overturn fatalities examined. New OECD TAD/CA/WD(2014)8/REV1 defines the maximum forces to manually actuate a foldable ROPS. Forces measured on existing foldable ROPS far exceed those stated maximums. A simple mechanical foldable ROPS lift assist can ease in the raising and lowering of ROPS. A summary of foldable ROPS forces and the benefits of the ROPS lift assist will be presented.

Keywords: ROPS, Foldable, OECD.

Performance evaluation of a commercial tractor stability control system

Casazza C., Rondelli V., Martelli R.

University of Bologna. Department of Agricultural and Food Sciences (DISTAL)

Viale G. Fanin, 44- 40127 Bologna, ITALY

Tel 0039 051 766632, Fax0039 051 765318, valda.rondelli@unibo

The study takes origin from the increasing development of aftermarket devices to evaluate tractor rollover risk on the basis of dynamic parameters detected by sensors.

Aim of the research was a tractors rollover risk assessment in normal field operation, using a commercial device to evaluate the activities at higher rollover risk for the agricultural operators.

Five tractors used in the experimental farm of the Bologna University were monitored in the 2013 year. Each tractor was equipped with a stability control system based on a hardware multisensory device, a software risk index algorithm and an integrated position information system for tractor localizing. The detected parameters and tractors position were accessible via a dedicated web site. Fourteen transceivers were connected to implements for recognition when coupled to the tractor.

Preliminary tests demonstrated that the tilt sensors used in the device did not provide high performance when the tractors were subjected to sudden operative changes. The risk assessment, in fact, was based on a quasi-static evaluation of stability conditions.

On the other hand the device seemed suitable to monitor dangerous practices in the normal operation of the tractor; the system could represent a good tool to educate unskilled drivers, becoming an acceptable compromise between safety evaluation and farm management.

Among the monitored operations the liquid manure spreading and the round baling were the ones at highest risk, while plough and rotary harrow were considered as tractor stabilizers.

Keywords: Rollover, Safety, ROPS.

Non-continuous rolling in modern narrow-track tractors

Franceschetti B., Capacci E., Rondelli V.

University of Bologna. DISTAL, Department of Agricultural and Food Sciences.

Viale G. Fanin, 44 - 40127 Bologna, ITALY.

Tel 0039 051 766632, Fax 0039 051 765318, valda.rondelli@unibo.it

Tractor rollover is one of the most hazardous event for the operator. Roll-Over Protective Structure (ROPS) was introduced to protect operator passively. In the specific case of protective structures in front of the drivers and fitted on wheeled narrow-track agricultural tractors, ROPS has to avoid the non-continuous rolling in the event of lateral rollover. Mathematical Model is included in the preliminary tests of the standardised testing procedures issued by the Organisation for Economic Co-operation and Development in order to check non-continuous rolling behaviour in narrow-track wheeled agricultural tractors. Modern narrow-track tractors fitted with rubber-tracks are currently designed but the standardised calculation does not cover the rubber-track tractors. The aim of the evaluation was to analyse the lateral tractor rollover behaviour as affected by the replacement of the tyres with the rubber-tracks. In the tested tractor the fitment of rubber-tracks replacing the rear wheels showed to increase the tractor mass and to affect the position of Centre of Gravity causing a downward and rearward shift with respect to the equivalent wheeled tractor. The track-ground interaction was different compared to the tyre-ground one. Mainly, the behaviour of the rubber-track with respect to the tyre at the state of unstable equilibrium under full load caused the rotation of the tractor around the outer edge of the track.

Keywords: ROPS, Rollover, Stability, Rubber-Track.

Experimental determination of operator perception of tractor instability

Ochoa Lleras N., Murphy D., Brennan S.

Penn State University

University Park, PA, USA.

Tel +1 814-865-7157, Fax +1 814-863-1031, djm13@psu.edu

Tractor instability is a major cause of serious injuries and fatalities in the agricultural industry. Thus, preventing tractor rollover can have a vital impact in reducing injury risk and saving lives of operators. This study presents preliminary experimental results on the perception of tilt angles. Using a novel tractor driving simulator developed at Penn State, a testing protocol was implemented in order to evaluate the ability of subjects to remember poses at various roll-pitch combinations. Results suggest that roll and pitch are both systematically underestimated, the former more severely than the latter. They also show no statistically significant correlation between the effect of pitch angles on the perception of roll, but do provide an upper bound on typical perceptual errors. These pilot-test results will serve as the basis of a comprehensive study with a wider subject pool. The bigger goal in this effort is to develop rollover alert systems that can prevent these accidents from happening. In that regard, the data obtained from this experiment can be useful in the design and tuning of predictive rollover alerts that promote safe operation of farm tractors, using human perception errors of roll and pitch to guide the thresholds at which warnings should be initiated in each of these directions.

Keywords: Rollover Protective Structure, Tractor Stability, Risk Perception, Stability Research.

Narrow-track agricultural tractors: a survey on the load of hand-operated foldable roll-bar

Pessina D., Facchinetti D., Giordano D.M.

Dept. of Agricultural and Environmental Sciences, University of Milan

Via Celoria, 2 – I 20133 Milan, ITALY

Phone +39 02 503 16876 – fax +39 02 503 16845, domenico.pessina@unimi.it

To protect the operator in case of overturning, the narrow-track tractors (used in vineyards and orchards) can be equipped with a ROPS consisting of a 2-pillars front mounted foldable roll-bar.

The handling of this type of ROPS, in particular the transition from the horizontal (rest) to the vertical (protection) positions, is generally operated through two removable pins managed manually by the driver of the tractor. Apart the time necessary to perform some times a day this operations sequence, a moderate/medium physical load should be also required, given that often these roll-bars have a mass of some tens of kilograms. The reality is indeed quite different, since neglect and a poor attention to safety lead to the condition in which the foldable roll-bar remains continuously in the rest condition and is no longer moved back in the vertical (protection) position. Several roll-over accidents were fatal for the operator because the tractor, although equipped with a 2-pillars front mounted ROPS, at the time of the event had the roll-bar in the horizontal (rest) position, so assuring no protection to the driver.

This issue is quite serious. To remove at least one of the problems for the proper managing of this type of ROPS, the OECD have recently updated its Code 6, by introducing an optional test dealing with the manual handling of the front mounted roll-bar, providing a maximum load of 100 N.

Several tests on new roll-bars were carried out to ascertain the respect of this limit. The 100 N value is generally exceeded, so showing its criticism. Indeed, a more appropriate reference for the manual handling should be in this case higher load values (up to 250 N) already provided by several Standards for non-continuous tasks.

Keywords: Tractor Overturning, Front Mounted ROPS, Raising Force.

Design Considerations in fixture development to Retrofit ROPS on Agricultural Tractors

Shrivastava A. K.⁽¹⁾ and Tewari V. K.⁽²⁾

⁽¹⁾ *SG College of Agriculture and Research Station, Indira Gandhi Krishi Vishwavidyalaya, Jagdalpur (CG), India. Telefax: +91-7782-229360, +91-9406866946 ashish.uo@gmail.com,*

⁽²⁾ *Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur (WB), India.*

Tractor population has reached about 5 million in India. Though being the largest tractor market, rollover kind of accidents have not got attention so far. Recent tractors are being equipped with safety devices such as SMVE, NSS and safety guards on moving parts. Stability sensors are also being thought-off to inform overturning situation. In fact, ROPS retrofitting is one of the best engineering controls for passive safety of rollover accidents through ROPS is not compulsory accessories of tractors. Therefore, operators' safety is at stack. Regulations coupled with design variation of various tractor models are hindering the use of market/common ROPS for retrofitting on tractors. Therefore, investigation has been planned to develop a fixture to retrofit ROPS to insure operators' safety.

To develop mounting fixture, medium range horse power tractors has been targeted. Two way approaches have been adapted to design fixture. First, in view of design of structural mount point and second, ROPS cross sectional view point. Structural mounting location is nothing but axle housing of various tractor models. These all have been clustered based on geometrical similarity of axle housing followed by strength predication of selected pre-ROPS axle housing. Alike to axle housings design parameter of ROPS were also considered.

It was found that most of the axle housing were circular in shape so as structural mount point. The critical diameter and thickness were varying about 90-250 mm and 14-18 mm respectively. Developed fixture could accommodate maximum of 70 mm × 90 mm prismatic cross section and up to 90 mm diameter of circular. Fixture was found capable of satisfying requirements of IS: 11821(Part 2) identical to OECD test code. Proper implementation of fixture along with regulation expected to reduce fatalities of tractor operator.

Keywords: ROPS Retrofitting, Axle housing, Design.

TOPIC 7

“ROPS”

POSTER PRESENTATION

Evaluation of the stability of an articulated farm tractor using mounted implements on hillsides

Bietresato M.⁽¹⁾, Carabin G.⁽¹⁾, Vidoni R.⁽¹⁾, Gasparetto A.⁽²⁾, Mazzetto F.⁽¹⁾

⁽¹⁾ *Free University of Bozen-Bolzano, Faculty of Science and Technology– FAST, Piazza Università, I-39100 Bolzano, Italy. Tel. +39-0471-017181, fax +39-0471-017009, marco.bietresato@unibz.it.*

⁽²⁾ *University of Udine, Dipartimento di Ingegneria Elettrica, Gestionale e Meccanica–DIEG, Via delle Scienze, I-33100 Udine, Italy.*

When introducing a new farm tractor in the market, manufacturers undergo a tight homologation path under the supervision of the OECD centres technicians. Two of the most requested tests, although not mandatory for the commercialization of a tractor, are the individuation of the centre-of-gravity and of the lateral rollover angle on a tilting platform. The results of these tests are very interesting for the technical characterization of a vehicle but still far from its real working conditions, even if the tilting platform test forecasts, for example, the presence of fuel in the tank and the use of some weights to simulate the driver. Indeed, in this last test, no mounted implement (or equivalent mass) is connected to the tractor, hence limiting a lot the use of the results of the described tests.

Therefore, a numeric stability simulator was developed to overcome this problem, thus managing the variety of the possible implements to be connected to a tractor and giving the farmers effective indications concerning their vehicles' safety while working on hillsides. This simulator, based on a Newtonian approach, is able to compute the stability of a vehicle formed by a tractor and an implement.

It was used to verify the possibility of safety using some common mounted implements with a compact wheeled articulated tractor, specifically designed to work within terraced orchards/vineyards, common in mountain areas. This tractor was chosen because of its particular architecture: it gives the tractor a higher agility and a shorter turning radius than conventional tractors with the same dimensions, but also a very different stability behaviour, maybe not completely predictable in all situations by inexperienced drivers.

Keywords: Numerical Stability Simulator; Tractor+Implement Stability; Articulated Farm Tractor.