Accident at work with fertilizer distributors in Austrian agriculture

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Abstract: Accidents with fertilizer distributors at work happen in the Austrian agriculture every year. In accordance with Machinery Directive 2006/42/EC and the standards ISO 4254-1 and DIN EN 14017, fertilizer distributors undergo a risk assessment before construction and market entry to ensure their complying with these legal recommendations and to eliminate largely the risk of injury for the operators. To determine the accident scenarios, causes, and technical solutions, a narrative analysis of 14 reports of accidents that led to moderate and serious injuries from 2008 to 2010 was done, eight victims interviewed, and seven accident machines and eight new ones, which were sold in 2013, evaluated according to applicable regulations. Mostly farm managers were involved in accidents with mineral fertilizer distributors during coupling and uncoupling and filling mainly on the farmyard. During coupling and uncoupling, farm managers collided with the machine itself, and during filling with the fertilizer chunks of the big bags. Falls from the machine were caused by slips and missteps during fertilizing, filling, and cleaning tasks. Farm managers were hit by the machine by coming into contact with the running spreading unit during fertilization and maintenance tasks. The accident machines showed large and the new machines low permanent deficits in instruction and warning notices as well in constructional execution. Potential constructive improvements are the standardized provision of instructions and warnings, standard-compliant boarding (ladders, grab rails, platforms, etc.) and loading means (lift arms, platforms) for filling and monitoring the container contents, sufficient space or hydraulic coupling elements for coupling, uncoupling, and unfolding of spreader units, and protective devices for agitators in new machines. In the case of the accident machines, the optimization is limited to retrofitting with existing auxiliary equipment available from the manufacturers due to the applicable warranty provisions.

Keywords: Agricultural machinery, fertilizer distributors, accident analysis, statistical analysis

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1 Introduction

The national European Statistics on Accidents at Work (ESAW) database of the Austrian Workers Compensation Board (AUVA) shows that accidents with solid fertilizer distributors occur in the Austrian agriculture every year (Quendler et al., 2013). Fertilizer distributors are used for the application of mineral fertilizers to increase the yield on the one hand and to improve the valuable contents of food and feed on the other hand (EUROSTAT, 2011). Compared to other European member states, the mineral fertilizer use in Austria is low because of the extensively used (58%) and organically farmed grassland where mineral fertilizer is used to a small extent. Additionally, this situation is accelerated by funding measures (BMLFUW, 2013). Due to the sharp increase in the prices of raw materials, especially the sharp rise in natural gas prices, the application amount of plant nutrients on agricultural land in Austria and nitrogen in Western Europe is declining (FAO, 2012; BMLFUW, 2013). They are partly substituted by plant nutrients from compost, especially in organic farming.

For the application, centrifugal and pneumatic

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distributors are used. In the Austrian and the European agriculture, the centrifugal distributors have a market share of over 90%, and they are the machines involved in occupational accidents in Austria. Centrifugal distributors consist predominantly of a spreading unit with metering devices and stray discs or pendant tube (Marquering and Scheufler, 2006).

The health and safety requirements of a machine that is distributed on the market must comply with Machinery Directive 2006/42/EC. The machine must be subjected to a risk assessment, which includes a risk analysis and evaluation, to detect security issues as early as possible and resolve them during the design process. Compliance with the Machinery Directive is confirmed through the EU declaration of conformity and the "Conformité Européenne"(CE) marking (Schauer et al., 2003).

The fundamental safety requirements of the European Commission Machinery Directive are specified in the harmonized standards ISO 4254-1 (Agricultural machinery safety - General requirements) and EN 14017 (Agricultural and forestry machinery – Solid fertilizer distributors – Safety) according to the current state of technology. They stipulate that solid fertilizer distributors shall have permanent markings providing information about company- and machine-specific characteristics, as well as warnings about moving parts, fertilizer ejection, and protective devices. For hitching and unhitching, sufficient space between machine and tractor must be provided. To avoid contact with running or rotating machine parts (spreading units, agitators), normalized guard rails and protective bars are required (DIN EN 14017, 5.3, 5.4). To reach places for service work and filling the machine, which are higher than 2.0 and 1.5 m, they must be equipped (ISO 4254-1, 4.8, DIN EN 14017, 5.5) with appropriate platforms for the operator and, at a height of more than 0.55 m, standardized steps and ladders (non-slip, slope >70°, with the same step distances, boundary, handholds or handrails for three-point contact).

The national ESAW database confirms that accidents with solid fertilizer distributors happened mainly because of the deviation of "loss of control", followed by "body movement", "fall of a person", and "breakage, bursting, splitting, slipping, falling, and collapsing of material agent". Contact that led to an injury included "being trapped, crushed, etc." , "contact with a sharp, pointed, hard or rough material agent" , "horizontal or vertical impact with or against a stationary object" , and "being hit by objects". They occurred during "operation of a means of transport", "manually handling of objects", "walking, running, going up, going down, etc.", and "operating the machine" (Quendler et al., 2013).

There is a lack of information and data about accident courses and causes which indicate the accident-causing human-machine interaction and the involved machine parts in agricultural terminology, as well as about safety evaluations of new and used solid fertilizer distributors. Studies from other countries about accident scenarios and involved machine parts of solid fertilizer distributors are not available. The detailed Canadian Agricultural Injury Report (2011) and the study of Javadi and Rostami (2007) about accidents with farm machinery do not mention solid fertilizer distributors as an accident-causing machine type separately. According to Jones and Lyons (2003), the ESAW variables do not yield any information about accident causes, in particular the contact with work equipment or its parts that caused the accident, which is necessary for the sustainable deduction of preventive solutions.

The aim of this study is to determine the course and causes of solid fertilizer distributor accidents in the agricultural jargon, and the safety deficits of accident and new machines according to legal requirements, and to deduce technical preventive approaches.

2 Materials and methods

Literature, reports about accidents with used machines and a comparative evaluation of new machines were used to determine the accident scenarios and technical solutions for the prevention of accidents.

For the analysis, 14 of the 15 accident reports about recognized occupational accidents occurring during the period 2008 to 2010 were selected from the database of the Social Insurance Institution of Farmers (SVB) and the Austrian Workers Compensation Board (AUVA). The

reports were anonymized and provided in coded form for the evaluation. Not all accidents with solid fertilizer distributors that occurred in agriculture were documented in the database, but only those for which an accident insurance claim was made. These are mainly accidents with moderate and severe injuries. Probst and Graso. (2013) refer to a similar quality of documentation of reported occupational accidents of the national statistics of other European and non-European countries, which did not take into account 60% to 80% of all occupational injuries. In comparison with press reports, however, those were more informative and easier to access than press, police, and hospital reports. Mannering and Bhat (2013) refer to similar results for studies of car accidents.

To clarify the lack of information about the accident scenarios "fall from the machine" and "collision with the machine," eight injured persons were contacted and interviewed. The evaluated accident machines of those surveyed had a volume capacity ranging from 500 to 1,600 kg and were mostly older than 10 years (75.0%, 6/8). To verify the identified safety deficits of accident machines in contrast to new machines, eight new machines from four manufacturers were evaluated according to the evaluated accident causes and applicable standards and guidelines.

The basis of the accident analysis was the human-machine-environment system. The system elements, relationships, and limitations, as well as the methodological approach were identified and determined according to safety considerations and information provided by those people that were directly and indirectly involved in the accidents.

The relevant text passages or keywords were filtered from the accident reports and entered into a table calculation program. The narrative text analysis, already used by Bunn et al. (2008) for the analysis of fatal tractor accidents in Kentucky on the basis of press reports, was carried out. The accident reports had largely been completed by hand and did not contain any coded information, so that the analysis was done manually and not computer based.

Due to the disparity of report templates and various reporting persons, some relevant responses were available in different passages of the accident reports. The variables which were identified in the accident reports are the year of the accident, employment status of the victim, accident site, working process, accident course and cause, type of injury, injured body parts, and injured body side. The categorization was made after reviewing all accident reports. The categorization was chosen on the basis of existing literature (Canadian Agricultural Injury Report, 2011).

The interviews with incidental victims were conducted in person or via telephone. For this purpose, a semi-standardized questionnaire was used. To clarify the lack of information about the accident-causing human-machine-environment interaction, the interviewees were asked to provide further information about the following factors: machine-, human-, and environment-related accident factors, aggravating and mitigating factors of the severity of injury, accident course, suggestions for constructive changes and for the integration of additional safety technologies into the machine and the operation. Javadi and Rostami (2007) conducted a survey among accident victims in Iran about the causes of machine accidents and the human-, machine-, and environment-related factors because of the lack of a national database.

The additional evaluation of new machines was carried out due to the fact that an essential part of the accident machines corresponded to older models and the fact that safety deficits may also exist in new models. The evaluation sheets included the accident-relevant parts of the machines involved in accidents categorized into size class, brand, and type for the evaluation in accordance with applicable safety and design requirements of Machinery Directive 2006/43/EC, DIN ISO 4254-1, and EN 14017. The analyzed and surveyed information was entered into the table calculation program of Microsoft Excel®, categorized, and described in Microsoft Word®. The data were analytically tested with the chi-square test.

3 Results and discussion

3.1 Results of the narrative text analysis

In Austria, 14 occupational accidents with solid

fertilizer distributors were documented between 2008 and 2010. In six of 14 accident cases there existed no information about the status of persons injured, the workplace were mentioned in seven out of 14 accidents analysed. The injured persons were exclusively farm managers (100%). This high percentage does not correspond with the share (62%) of farm managers in Austria (Statistik Austria, 2010). Mechanical field work is done mainly by male workers in the Austrian agriculture.

Table 1 Employment status, workplace, and process parameters of occupational accidents with solid fertilizer distributors in the Austrian agriculture (2008-2010)

Parameters	Persons, n
Employment status	(n=8)
Farm managers	8
Workplace	(n=9)
Farmyard	4
Farm buildings	3
Arable land, meadows, pastures	1
Public places	1
Work process	(n=14)
Hitching/Unhitching the machine inclusive power source	6
Filling up with fertilizer	3
Fertilizing	3
Maintenance of the fertilizer distributor	2

The accidents with solid fertilizer distributors occurred mainly in the farmyard area (44.4%) and farm buildings (33.3%) in the course of hitching and unhitching (75.0%) and filling (25.0%) of the machines. Accidents on arable land, meadows, and pastures (11.1%) happened due to fertilizing work and in public areas (street) (11.1%) during filling of the machine. Other studies on agricultural machinery verify that an increased number of accidents occurred in farm buildings (25%-47%), fields (18%-45%), and transport roads (8%) (Hwang et al., 2001; Gil Coury et al., 1999). The distribution of accidents according to workplace varied strongly with the respective machinery.

Hitching and unhitching of the machine (42.9%), filling of the distributor (21.4%), fertilizing (21.4%), maintenance (7.14%), and cleaning (7.14%) were the work processes which most frequently led to accidents with solid fertilizer distributors. Comparable studies on different agricultural machinery accidents show a similar incidence rate for accidents during maintenance and repair work (11%-24%), as well as during the operation of machines (16%-21%) (Rasmussen et al., 2000; Hwang et al., 2001), and in the course of hitching and unhitching of machines (26%) (Gustafsson et al., 1991).

The contact (collision) with the machine (50.0%), being caught by the machine (14.3%), and the fall from the machine (35.7%) were the various accident courses which occurred due to different accident causes.

Accidents by contact (collision) with the machine tended to be caused predominantly by machine-related issues (insufficient space between machine and tractor) (57.1%) and by human actions (improper handling and operation) (42.9%) rather than environmental factors. The fall from the machine was more frequently caused by environmental (80.0%) than by human factors (20.0%). Accidents by being caught by the machine were exclusively caused by mechanical factors (100%) (p-value 0.0146).

The fall from the machine (35.7%) occurred through slipping (80.0%) during fertilizing (50.0%), filling, and cleaning tasks (both 25.0%), and through missteps (20.0%) during filling the distributor. Falling accidents from farm machinery resulted mainly from missing or not standardized boarding means, steps, ladders, and platforms. Comparable studies (Pickett et al., 1999, 2001; Hwang et al., 2001; Gil Coury et al., 1999) on accidents involving different agricultural machinery found frequencies of falls from a machine of 4% to 17%. Those studies, however, do not provide any information about the extent of boarding means, steps, ladders, and platforms on the machines.

Table 2 Incidental course, -cause, and safety deficiencies of solid fertilizer distributors in the Austrian agriculture (2008-2010)

Parameters	Persons, n
Incidental course	(n=14)
Contact (collision) with machine	7
Fall from machine	5
Being caught by machine	2
Incidental cause	(n=14)
Human	8
Machine	5
Environment	1
Safety deficiencies	(n=14)
Operation/Workplace/Workwear	9
Construction fault/-deficit	5

The contact (collision) with the machine (50.0%) resulted from slipping during disconnecting the hydraulic tubes (14.3%), loosening blockings (28.6%), raising the hydraulic lever (14.3%), being caught (14.3%), and colliding with the support leg (14.3%) during hitching (57.1%) and unhitching (28,6%) of the machine, and loosening a fertilizer chunk out of the Big Bag (14.3%) during filling (14.3%). The accidents through collision with the machine resulted from the limited space between the machine and the tractor during hitching and unhitching. Gil Coury et al. (1999) and Pickett et al. (1999) found frequencies between 20% and 23% for accidents caused by a collision with different agricultural machines.

Running or rotating machine parts (spreading units) (100%) were the main accident cause of being caught by the machine (14.3%) during fertilization and maintenance work (each 50.0%). The lack of protective devices on the running or rotating machine parts (spreading units and agitators) was responsible for such accidents. In comparable studies, the relative frequencies of being caught by the machine through machine parts of other agricultural machines (30%) are higher than those with solid fertilizer distributors (Gil Coury et al., 1999).

Safety deficits were improper handling in connection with workplace design and missing workwear (64.3%), as well as construction faults (35.7%). For each accident, the safety deficits were derived from the information on accident causes in the accident reports. This parameter is not recorded in accident reports in Austria or other countries; information about it, however, can help to derive preventive measures efficiently and sustainably.

Improper handling and workplace design and missing workwear caused collision accidents more frequently (77.8%) than being caught by the machine (22.2%). Construction deficits of machinery produced mainly accidents through the fall from the machine (100%). The improper handling and workplace design and the missing workwear led more often to human (66.7%) than mechanical causes of accidents (33.3%). Mechanical causes of accidents (p-value 0.0009) exclusively resulted from construction deficits (100%).

The injuries occurred primarily on the upper extremities (57.1%), followed by the lower extremities (21.4%), the upper body (14.3%), and in the head area (7.14%). Injuries occurred predominantly and to similar frequencies to the right (50.0%) and the left side of the body (41.7%).

Table 3 Injury type and affected body parts in accidents with solid fertilizer distributors in the Austrian agriculture (2008-2010)

Parameters	Persons, n
Injury type	(n=14)
Fractures	5
Wounds	4
Multiple injuries	3
Amputations	1
Bursitis	1
Body parts	(n=14)
Upper extremities	8
Lower extremities	3
Torso	2
Skull	1

The most frequent types of injuries were fractures (35.7%), followed by wounds (28.6%), multiple injuries (21.4%), amputations, and bursitis (each 7.14%). These can happen in any accident, depending on the intensity of the contact with the machine. Studies on machine-related farm accidents show that wounds (25%-50%), fractures (10%-41%), and sprains (8%-39%) on the upper and lower extremities are the three most common types of injuries (Gil Coury et al., 1999; Hwang et al., 2001; Pickett et al., 1999).

3.2 Results of the survey

Nearly three quarters of the surveyed injured persons had read (71.4%) and understood (50.0%) the operating manual. Only 25.0% of the injured persons wore safety shoes, 50.0% wore workwear, and 37.5% work gloves.

Studies that deal with the wearing of workwear in agriculture mainly relate to the protection against different pollutants (dust, pesticides, exhaust gases), noise (noise), and environmental factors (solar radiation), and are available by Schenker et al. (2002), Dorman and Havenith (2009), and Nielsen and Moraski (1986). Wearing workwear aims to protect the human against the abovementioned factors on the one hand and to reduce heavy workloads on the other. Specific scientific studies on wearing workwear to avoid accidents caused

by collision, being caught by the machine, and falling from the machine have hitherto not been conducted. Special leaflets concerning safety at work provided by various insurance organizations (SVB, AUVA) in Austria highlight the safety benefits of wearing workwear (safety shoes, work gloves, clothing).

The improper handling of the machine (75.0%) due to habit (33.3%), the machine design (33.3%), and the machine construction in connection with machine defects (33.3%) led to accidents caused by the fall from the machine. The machine parts involved included the container of the distributor, missing boarding means, steps, ladders, and platforms, the spreading unit, and the hydraulic top link (25.0%, respectively). Missing boarding means, steps, ladders, and platforms were mentioned by the victims (75.0%) as contributing to the accidents. Hurry and stress (50.0%) and factors that hampered the work performance (noise, lighting, etc.) (25.0%) were also responsible for the accidents.

In 50% of the accidents caused by falling, dirty and dusty machine parts were recognized as disadvantageous environmental factors. Aggravating factors were the hard ground and the fall onto the machine parts (25.0%, respectively). Only in one case could the wearing of a work jacket be identified as an alleviating factor in an accident caused by falling (25.0%).

For preventing these kinds of accidents, 50.0% of the victims stated that a calmer and more focused operation (75%) and a complete dismounting from the machine (instead of jumping from it) (25.0%) could help to avoid falling from the machine. For 75.0% of the victims of accidents caused by falling, such accidents could be avoided by proper handling and improved workplace design. Half of the victims of accidents caused by falling said that they had changed their processes of operation and that they had become more careful in the workplace (50.0%). As a constructive change to the machine, 25.0% of the victims suggested a hydraulic folding-out of the distributor.

The collision with the machine (100%) happened due to machine deficits (50.0%) and the sub-optimal operation (50.0%). The hydraulic systems of tractors in connection with the container of the distributor (50.0%) and the three-point hitch (50.0%) could be identified as machine parts involved in the collision with the machine. Machine-related construction disadvantages are a lack of space between the tractor and the machine during hitching and unhitching (100%).

The accidents were aggravated through hurry and stress (25.0%), physical overload with hurry and stress (25.0%), and hurry and stress with fatigue (25.0%). As aggravating factors of injuries, the size of the machine, missing workwear (gloves) (25.0%), lack of space (25.0%), and lack of space with darkness in the workplace (25.0%) could be identified. Wearing work gloves (25.0%) and having no protruding sharp objects on the machine (25.0%) had defusing effects. According to Lyman et al. (1999) and Zejda et al. (1993), hurry and stress (18%), fatigue (2%), and health problems (illness) have a very large impact on the courses of accidents involving workers (managers, family members) in the agricultural sector.

To avoid these accidents, 75.0% of the surveyed victims said that it was necessary to work in a more focused and careful manner. A change in the workplace by working more carefully was made by 75.0% of the surveyed victims after the accident. Suggestions for constructive improvements were the installation of an improved hydraulic coupling system (25.0%) and a hitching system with more space for the operator between tractor and machine (25.0%).

3.3 Evaluation of accident machines and new machines

Substantial deficits existed in terms of the durable identification on accident machines, while durable identification was predominantly present in the evaluated new machines. Missing information on the accident machines included the name and address of the manufacturer, construction year (85.7%), type (42.9%), serial number (28.6%), maximum loading of the container (42.9%), curb weight (85.7%), maximum rpm (71.4%), and CE marking (28.6%). Regarding the evaluated new machines, the information about the maximum rpm (12.5%) was missing on only one machine. The identification contents of the construction year, curb weight, and maximum rpm on new machines tended to be

more complete than on accident machinery (16.7% and 50%) (p-value <0.05). Warnings about moving parts, fertilizer ejection, and falling from the machine tended to be missing on accident machines more frequently than on the evaluated new machines (50%) (p-value <0.03).

Standardized boarding means, steps, ladders, and platforms after Machinery Directive 2006/42/EC and DIN EN ISO 4254-1 were predominantly missing on all accident-causing machinery. Only one new machine (12.5%) had a ladder which fulfilled the applicable regulations regarding the standards (non-slip, three-point contact, limiting). The fall from machinery or parts of buildings is one of the most common accident courses in the agricultural sector; therefore, machines should be better equipped with standardized boarding means, steps, ladders, and platforms (slip resistance, incline, grab bars), which can be replaced according to wear and tear. Prodinger et al. (2011) found a high number of fall accidents while mounting and dismounting mainly caused by improperly designed steps (65%) on tractors.

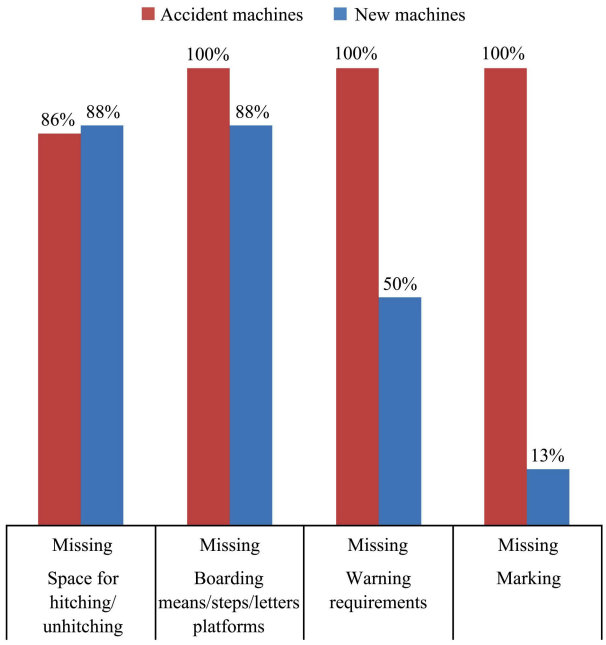

Figure 1 Evaluation of differences in construction of new and accident machines (2013), (n=7, n=8)

The loading height of accident machinery tended to be over 1,250 mm (85.7%) and of the new machinery below 1,250 mm (87.5%), while for the first mentioned loading height situations ladders and platforms are required according to the legal regulations (p-value 0.005).

The height of the lower coupling points of the three-point hitch of the tractors could be matched with the lower points of 83.3% of the accident and of 87.5% of the new distributors. The required stability was present in all accident and new machines; no evaluated machine had a support leg for stability. The hitched accident machines had insufficient space between distributor and tractor for coupling rotating power elements (100%). In 62.5% of the new hitched solid fertilizer distributors, sufficient space between tractor and machine for the hitching task was missing and in 37.5% a partially existing space for hitching power rotating elements between solid fertilizer distributor and tractor was available. Only one of the evaluated new solid fertilizer distributors (12.5%) had a device for increasing the space on one side for coupling the power drive and control elements between the distributor and the tractor. In 37.5% of the new machines, it was possible to couple power rotating and control elements in a partially adequate space between (before hitching) the distributor and the tractor.

On accident machines (71.4%), protecting devices or elements (safety bar) against contact with the spreading unit to the front, back, and sides tended to be missing more often than on new machines (12.5%) (p-value <0.05). Similarly, protective grids were more frequently missing on accident machinery (28.6%) than on new solid fertilizer distributors (100%) (p-value 0.006).

4 Technical solutions

To avoid fall accidents, standardized boarding means, steps, ladders, and platforms, inspection windows, level indicators or other measures for monitoring the container should be made available. Step-ups directly on the machine are used to verify the tank contents and are offered as standard or optional equipment by manufacturers. Integrated lifting arms reduce the incidental risk when filling the distributor with big bags. Integrated pressure values on the hydraulic cylinder of the lift arm and the hydraulic operation of the tarpaulin provide easy operation as well as additional safety during filling. For small-scale platforms, indicators and warnings must be available to show the operator the end

of the platform and the risk of falling when climbing on the machine. Due to the absence of boarding means, steps, ladders, and platforms on new and used machines, existing additional equipment of manufacturers should be upgraded or work tools (ladders) should be used to prevent falls during the filling of the distributor.

In order to reduce accidents caused by collision with the machine during hitching and unhitching of power rotating and controlling elements, it is necessary to increase the space (at least on one side) for the operator between distributor and tractor. For older machines in the agricultural practice, lower link catch hooks (tractor) and catch sockets (machine) in connection with a hydraulic top link can be used to prevent collision accidents with the machine. These allow the hitching of the machine to the tractor from the tractor seat. Another alternative is to design the power drive and control elements so as to allow more space for the operator before hitching the machine on the tractor. Systems that allow the operator to hitch and unhitch machines fully or partially automatically from the tractor seat are already available on the market.

As a future-oriented approach against accidents through being caught by running or rotating machine parts (of the hitched machine), safety devices that allow the operator to shut down the running or rotating machine parts when leaving the seat (tractor) should be made available. Person detection systems can achieve the same effect and help to protect people near dangerous machine parts. Simplest preventive measures are the professional upgrade of protective devices (subject to availability) on the rotating and running machine parts of accident machines.

References

BMLFUW. 2013. Der Grüne Bericht. Bericht über die Situation der österreichischen Land- und Forstwirtschaft. AV+Astoria Druckzentrum GmbH, Wien.

Bunn, T. L., S. Slavova, and L. Hall. 2008. Narrative text analysis of Kentucky tractor fatality reports. *Accident Analysis and Prevention,* 40(2): 419-425.

Canadian Agricultural Injury Report. 2011. Agricultural Fatalities in Canada 1990-2008. Access data: Feb. 2014 http://www.cair-sbac.ca/wp-content/uploads/2012/03/National-Report-1990-2008-FULL-REPORT-FINAL-EN.pdf.

ISO. 2008a. Standard ISO 4254-1:2008 'Agricultural machinery – Safety – Part 1: General requirements'. ISO - International Organization for Standardization, Geneva, Switzerland.

DIN EN 14017. 2009: Agricultural and forestry machinery – Solid fertilizer distributors – Safety. Deutsches Institut für Normung, Beuth Verlag, Berlin.

Dorman, L.E., and G. Havenith. 2009. The effects of protective clothing on energy consumption during different activities. *European Journal of Applied Physiology,* 105(3): 463-470.

EC. 2006. Machinery Directive 2006/42/EC of the European Parliament and of the council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast). EC- European Commission, Brussels, Belgium.

EUROSTAT. 2011. Food: from farm to fork statistics. EUROSTAT Pocketbooks. Publications Office of the European Union, Luxembourg.

FAO. 2012. Current word fertilizer trends and outlook to 2016. Food and Agriculture Organization of the United Nations, Rome. Access data: Feb. 2014 ftp://ftp.fao.org/ag/agp/docs/cwfto16.pdf.

Gil Coury, H. J. C., S. Kumar, and E. Jones. 1999. Farm related injuries and fatalities in Alberta. *International Journal of Instustrial Ergonomics,* 23(5, 6): 539-547.

Gustafsson, B., G. Lindgren, and P. Lunquist. 1991: Near – Accidents in Agriculture. A survey of swedish studies. *Swedish Journal of agricultural Research,* 21(1991): 85-93.

Hwang, S., M. I. Gomez, A. D. Stark, S. Lowery, T. John, J. J. May, and E. M. Hallman. 2001. Severe farm injuries among New York farmers. *American Journal of Industrial Medicine,* 40(1): 32-41.

Javadi, A., and M. A. Rostami. 2007. Safety Assessments of Agricultural Machinery in Iran. *Journal of Agricultural Safety and Health,* 13(3): 275-284.

Jones, S., and R. A. Lyons. 2003. Routine narrative analysis as a screening tool to improve data quality. *Injury Prevention,* 9(2): 184-186.

Klindt, T. 2003. Bedeutung der EG-Maschinenrichtlinie für Landmaschinen-Hersteller. *Landtechnik,* 58(4): 258-259.

Mannering, F. L., and C. R. Bhat. 2013. Analytic methods in accident research. Methodological frontier and future directions. *Analytic Methods in Accident Research,* 1(1): 1-22.

Marquering, J., and B. Scheufler. 2006. Mineraldüngung an den Feldgrenzen. *Landtechnik,* 61(1): 16-17.

Nielsen, P., and R. Moraski. 1986. Protective Clothing and the Argicultural Worker. *American Society for Testing Materials, Philiadelphia,* 95-102.

Pickett, W., L. Hartling, R. Brison, and J. Guernsey. 1999. Fatal work-related farm injuries in Canada, 1991-1995. *Canadian Medical Association,* 160(13): 1843-1848.

Pickett, W., L. Hartling, H. Dimich-Ward, J. R. Guernsey, L. Hagel, D. C. Voaklander, and R. J. Brison. 2001. Surveillance of hospitalized farm injuries in Canada. *Injury Prevention,* 7(2): 123-128.

Probst, T. M., and M. Graso. 2013. Pressure to produce = pressure to reduce accident reporting? *Accident Analysis and Prevention,* 59(2013): 580-587.

Prodinger, L., E. Quendler, and J. Boxberger. 2011: Analyse von Unfällen beim Auf- und Absteigen von Traktoren. Masterarbeit, Universität für Bodenkultur, Wien.

Quendler, E., Kogler, R., Mayrhofer, H, and Boxberger., J. 2013. Comparative incident analysis of pressure cleaner injuries among emolyees on farms. In Proc. *XXXV Ciosta Conference*, 37-40. Billund, Den., 3-5 July.

Rasmussen, K., O. Carstensen, and J. M. Lauritsen. 2000. Indicine of unintentional injuries in farming based on one year of weekly registration in Danish farms. *American Journal of Industrial Medicine,* 38(1): 82-89.

Schauer, A., N. Rauch, J. Marquering, and A. von Chappuis. 2003. Europäische Norm für Mineraldüngerstreuer. *Landtechnik,* 58(2): 102-103.

Schenker, M. B., M. R. Orenstein, and S. J. Sameuls. 2002. Use of Protective Equipment Among California Farmers. *American Journal of Industrial Medicine,* 42(5): 455-464.

Statistik Austria. 2010. Agrarstrukturerhebung. Personen und Arbeitskräfte. Access data: Feb. 2014 http://statcube.at/superwebguest/login.do?guest=guest&db=deas1003.

SVB. 2012. Merkblatt – Ergonomie. Access data: Feb. 2014: http://www.svb.at/mediaDB/879925_Ergonomie%202012.pdf.

Zejda, J. E., H. H. McDuffie, and J. A. Dosman. 1993. Epidemiology of health and safety risks in agriculture and related industries-Practical applications for ruralphysicians. *The Western Journal of Medicine,* 158(1): 56-63.

Lyman, S., G. McGwin, R. Enochs, and J. Roseman. 1999. History of agricultural injury among farmers in Alabama and Mississippi: Prevalence, characteristics, and associated factors. *American Journal of Industrial Medicine,* 35(5): 499-510.