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# Safety Work as a Factor in Reducing the Number of Injuries of Tractor Operators

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**Abstract:** Modern agricultural production requires the use of agricultural machinery. Among all agricultural machines, the tractor is one of the most frequently used agricultural machines. In this paper, we perform a literature review and explore various safety hazards a tractor operator is exposed to. Next, we present the results of a work safety related survey we conducted in Osijek-Baranja and Vukovar-Srijem counties. We conclude the paper with a list of safety related observations we derived from our research.

**Keywords:** ergonomics; health; operators; safe; tractor

## 1 INTRODUCTION

Modern agricultural production must ensure the production of quality, quantitatively sufficient and market competitive food. For the most part, manufacturing processes in agricultural production are mechanized, which implies the use of sophisticated machines. By increasing the level of mechanization of a certain process, we reduce the percentage of human labor within them, which contributes to lower injury occurrences in workers who take part in the process.

Agricultural production is specific in that:

- production takes place in the open,
- technological processes are conducted mostly by driving an agricultural aggregate over the production area,
- doing certain technical operations is time constrained due to optimal agrotechnical deadlines,
- agricultural machinery is applied on multitude of terrains (plain, gentle slopes, big slopes),
- the machines used have seasonal character (except tractors), so they remain out of use for a while,
- work is usually done on surfaces which are significantly dislocated from urban environments, and frequently, to reach the production surfaces, the worker must traverse roads that were created by the movement of agricultural machines and are not suitable for the movement of most road vehicles (weighers)
- most frequently the work is being done by only one person (agricultural tractor operator),
- the work is conducted in spite of unfavourable weather conditions (fog, snow) when the visibility is lowered,
- in production they use protective agents and mineral fertilizers that are aggressive and harmful to human health and,
- children participate in agricultural work.

On the production surface usually, there is only the tractor operator who operates the aggregate (common in family farms). Therefore, the problem of the tractor operator injuring themselves is complicated by the fact that the operator has no other choice, but to give themselves first aid, call for medical assistance and wait for their arrival. Furthermore, very often the tractor is being operated by persons who are not acquainted with potential dangers that could occur to the operator (they were not trained to operate the tractor safely).

Agricultural tractor, as a fundamental agricultural machine, is used in nearly all branches of agricultural production (farming, animal husbandry, fruit growing and viticulture, and vegetable growing). It is intended for towing, powering attached machines, carrying attached tools and devices, and for transport. Modern agricultural tractors, technologically perfected, in addition to an educated operator, require well-organized servicing and preventive maintenance, which, if conducted regularly, will avoid the occurrence of breakdowns, ensure high operational reliability of the tractor, extend the service life and reduce the possibility of injury to the operator during operation. Employee injuries while performing certain production processes certainly have economic, health, social and organizational consequences.

The aim of this paper is to provide an overview of the dangers and harms to which agricultural tractor operators and persons working in agriculture are exposed, and to present the results of research into the safe operation of agricultural tractor operators.

### 1.1 Literature Review

During work, the operator of the agricultural tractor is exposed to the negative influence of numerous factors, which results in a decrease in the performance and quality of the work performed, the appearance of fatigue of the operator, which, along with a decrease in concentration, very often ends in their injury at the workplace.

In parts of the production process where we still have a significant share of human labor (auxiliary workers who fill the containers of mineral fertilizer spreaders with fertilizer, that is, the containers of seed drills with seeds, etc.), there is a risk of injury to participants in the production process during work.

Very often, injuries are the result of the carelessness of the operator (who does not notice another person in the working area around the tractor and thus the tractor runs into people or the tractor passes over certain extremities) or the person who performs the work of an auxiliary worker.

One of the specifics of agricultural production (on family farms) is the participation of children in production processes and their injury during work.

Investigating children's injuries while doing agricultural work in Požega-Slavonia County, authors [1] are found that as many as 30.6 % of respondents (out of 188 children) suffered minor or serious injuries. A special problem regarding the safety of children and adult members of agricultural households is manifested in the fact that monitoring measures (application of regulations, measures and protection rules) of the existing laws cannot be implemented over them, since they are not employed, and in order to reduce the number of injuries to children, it would be beneficial to educate the parents about working in a safe way, note the same authors.

Injuries of persons working in agriculture can occur:

- While coming to work,
- While working with a tractor and other self-propelled machines,
- During work on the supply of agricultural machinery (auxiliary workers),
- During troubleshooting of tractors, self-propelled and attachment machines,
- While participating in road traffic,
- While going to the production area and returning from it,
- During work with protective equipment,
- Due to fatigue,
- Due to recklessness,
- Due to inexperience,
- Due to alcohol and intoxicants,
- While returning from work,
- Inappropriate work speed,
- Bad weather conditions during work,
- Difficult working conditions (working on sloping ground, movement on soil with high humidity, etc.) and
- Lack of expertise (the tractor is driven by people who don't have a driver’s license).

Authors [2] are citing similar causes of injuries, indicate the need for continuous education of tractor operators through courses, regarding the proper use and maintenance of machines. Courses should be organized with the participation of all relevant institutions and associations.

Authors [3] are determine the factors that increase the risk of accidents with a tragic outcome in agriculture (tractor without a safety cabin, older age, people working alone, road, slope of roads and paths, canals and obstacles, tractor manoeuvres, traffic, single-axle tractors, trailer, repairs, too much load, falls, excessive amount of alcohol in the blood). The most dominant factors are the lack of a safety cabin in the event of a rollover, driving on roads and paths, and older age.

Operators and people working in agriculture are mainly exposed to mechanical hazards while working with tractors and other agricultural machines by authors [4]. The high incidence of injuries while working with machines is influenced by their age and correctness, the operator's work experience, fatigue and possible alcohol consumption during work. Therefore, it is necessary to educate all household members regarding the dangers they are exposed to during work, the consequences of their actions, as well as the correct use of machines and pesticides, note the same authors.

The largest number of injuries that occur during work in agricultural households are the result of mechanical hazards when working with agricultural machines and tools, and the main factors for the occurrence of these are the technical malfunction of the machines and the ability and condition of the operator (fatigue, alcoholism, etc.) by author [5].

Investigating injuries in agriculture in the United Kingdom (UK), author [6] are notes that injuries with a tragic outcome most often occur when working with machines, due to falls from a height and due to electric shock. The highest number of accidents during the year occur in the months of July, August and September, and the number of accidents in agriculture is significantly higher than in most other industries, notes the same author.

Analyzing a multi-year period (2004-2013) in which 2.892 traffic accidents involving tractors occurred, by authors [7] are state that the biggest cause of accidents with a tragic outcome was a tractor without a safety cab. Most of the accidents happened on intercity roads. The age of the operator over 45 is a factor that increases the probability of an accident, the authors warn.

Authors [8] are analyzing tractor accidents in agriculture and forestry in the Czech Republic with serious injuries and fatal outcomes, state that in the interval from 2009 to 2018, 89 accidents occurred, of which 72 accidents were with severe (serious injuries) and 17 accidents with tragic consequences. In all accidents, the tractors were driven by men, and the most common cause of accidents was non-compliance with the rules.

Authors [9] are analyzed agricultural accidents in the Republic of Austria (2008-2010) caused by tractors, self-propelled harvesting machines and transport machines and found that 1/3 of the accidents occurred due to overturning of the vehicle, and more than 10 % of the accidents that occurred is due to technical problems, slippery or muddy surfaces or poor vehicle handling.

Investigating the consequences of accidents that occurred while working with a tractor, authors [10] in the period from 1999 to 2003 in the Republic of Macedonia, found that out of a total of 101 tragically injured persons, 56.44 % were killed in traffic, and 43.56 % during work. The older age of the operator results in reduced sensory and psychomotor abilities, which leads to a higher number of injuries with a tragic outcome, according to the same authors.

Regular maintenance measures ensure the technical correctness of the tractor and the machine that is aggregated with the tractor, and since they are performed before the start of work, they should reduce the possibility of injury. Furthermore, these measures ensure the technical correctness of the tractor as a participant in road traffic. The number of traffic accidents involving tractors, the number of fatalities and injured persons are presented in Tab. 1.

The number of traffic accidents involving tractors has a decreasing trend from 360 accidents (2015) to 334 accidents (2019). The number of people killed compared to 2015 (5 people) managed to decrease to 3 people killed in 2017, but,

unfortunately, during 2018 and 2019, it increased to 9 people killed. The number of severely injured and slightly injured persons increased in 2018 and 2019 compared to 2015.

**Table 1** Number of traffic accidents involving tractors, number of fatalities, seriously injured and slightly injured persons for the period 2015-2019 [11]

| Year | Number of traffic accidents involving tractors | Number of people killed in an accident | Number of seriously injured persons | Number of persons who suffered minor injuries |
|---|---|---|---|---|
| 2019 | 334 | 9 | 28 | 56 |
| 2018 | 337 | 9 | 31 | 51 |
| 2017 | 334 | 3 | 21 | 48 |
| 2016 | 362 | 5 | 29 | 51 |
| 2015 | 360 | 5 | 18 | 40 |

Investigating the implementation of maintenance measures on family farms, Authors [12] are indicate that they are not performed well, which will certainly increase the possibility of tractor breakdowns, as well as traffic accidents, since tractors participate in road traffic.

In order to determine the agricultural tractor as a traffic safety factor, authors [13] are conducted research by surveying 107 family farms, where they found a high average age of tractors (17.7 years) and a high percentage of unregistered tractors (52.79 %) on family farms. The fact that even 23.33 % of technically defective tractors participated in public traffic is also worrying, according to the same authors.

By fulfilling the ergonomic requirements, to the greatest extent, the modern constructions of agricultural tractors enable comfortable, health-safe work, reducing the possibility of injury of the operator to a minimum. Unobstructed entry and exit to the workplace (minimizing the possibility of injury) is ensured by the installation of handrails and steps and ladders on tractors and self-propelled agricultural machines. In order to reduce the possibility of injury, the steps must have a high coefficient of friction with the sole of the shoe, the distance between the steps should be uniform, and the first step should be easily visible (even at night) to avoid the possibility of missing it when leaving the cabin [14].

Authors [15] are defined the minimum size of the workspace (Fig. 1) of the operator of the agricultural tractor, which must provide him with unhindered movements of his hands and feet, and at the same time be spacious enough so that the tractor driver is not injured.

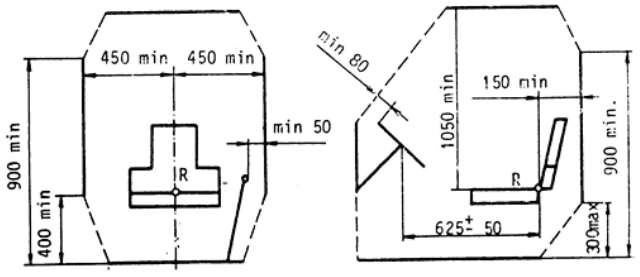


**Figure 1** Minimum values of the size of the workspace

Mechanical vibrations at the operator's workplace are the result of the tractor's movement, the operation of individual tractor assemblies (engine, transmission), the operation of the attached machine, etc. The negative impact of mechanical vibrations on the operator is manifested in their traumatic injuries at the place of their impact (direct impact) and indirect impact on nerves and nerve endings, which often results in disorders of the circulatory system, bones, nervous system, bones, joints, muscles, stomach, balance and others by authors [16].

The problem of mechanical vibrations is being solved by active and passive protection measures by author [17]. Active protection measures include: suspension of the front axle of the tractor, suspension of the entire tractor, an increase in the weight of the tractor and newer tire designs. In contrast to active measures, passive protection measures include the suspension of the tractor seat and the tractor cabin.

The limit and warning values of daily exposure during the operator's eight-hour working time to the hand-fist system are 5 $ms^{-2}$ and 2.5 $ms^{-2}$, respectively, and to the operator's trunk 1.15 $ms^{-2}$ and 0.5 $ms^{-2}$, [18, 19]. Investigating the level of vibrations of the hull that affects the operator when moving the tractor on different agrotechnical surfaces, seat materials and movement speeds, it was determined that not a single measured value exceeded the permissible limit value of 1.15 $ms^{-2}$ by authors [20]. The level of vibrations that affect the hand-arm system of the operator, when moving the tractor on different agrotechnical surfaces and at different speeds of movement, increases with the greater number of working hours of the tractor by authors [21]. The same authors indicate that all measured values did not exceed the permissible limit value of 5 $ms^{-2}$.

Noise is any unwanted sound that causes operator fatigue, reduced concentration, orientation problems, reduced ability to receive sound notifications and safety at work by authors [22]. Noise at the operator's workplace is a consequence of the operation of the engine, the operation of the transmission elements, the operation of the air intake system and the exhaust system, the operation of the hydraulic system, and vibrations due to the movement of the tractor on the production surfaces and vibrations of individual parts of the tractor [17]. The noise level at the tractor operator's workplace should not exceed 85 dB, otherwise the operator's hearing may be damaged.

Tractor cabs should be lined with material that absorbs sound well, and if the noise level is still above 85 dB at the operator's place, the operator should use personal protection against noise (ear plugs, ear protectors, etc.). Noise generation is certainly affected by the age of the tractor and the quality of its maintenance.

By measuring the noise inside and outside the operator's cabin at different engine revolutions (1100, 1800 and 2200 $rpm^{-1}$) and when standing and moving in relation to the number of working hours, it was determined that with the increase in the number of working hours' noise increases, except for external noise at 2200 $min^{-1}$ when standing and moving. None of the measured values exceeded 80 dB, which is favourable in terms of operator protection and safety by authors [23].

Agricultural machines work in an environment where there is a significant amount of dust. Dust in agriculture is

generated during tillage and harvesting by author [24]. In order to prevent dust from entering the tractor cabin (operator's workspace), filters are installed in it, through which the surrounding air passes before entering. If this protection is not sufficient, the operator must use a protective mask or a protective visor.

During work, the operator must be provided with favourable microclimatic conditions. Ensuring these conditions is complicated by the limited volume of the tractor cabin, large glass surfaces (windows and doors), working under a clear sky (exposure to solar radiation), heat radiation from the engine, etc.

If the operator is exposed to high temperatures at the workplace, this may result in heat stroke, and low temperatures may result in the freezing of certain parts of the body. In order for the operator to feel comfortable at the workplace, the air temperature must be 18-20 °C in the winter or 24-27 °C in the summer, the air flow speed 0.1 - 0.5 $ms^{-1}$, and the relative humidity 30 - 65 %, by author [25].

Modern constructions of tractors are equipped with cooling devices, cabins are lined with thermal insulation materials, which, along with the use of tinted and bevelled glass, as well as blinds and shades, provides the operator with favourable working conditions due to the microclimate.

When applying pesticides and other protective agents and mineral fertilizers, the operator may come into contact with dangerous substances. In addition to harmful substances, there is a risk of exhaust gasses entering the cabin, which contains carbon monoxide among other dangerous and harmful gasses.

During the application of protective agents (spraying, spraying), aerosol droplets are formed, which must never reach the operator's workplace. Therefore, the surrounding air will pass through a filter before entering the cabin. To prevent the entry of dangerous particles into the cabin through the openings through which the control levers, hydraulic hoses, etc. pass, seals must be correct, and there must be a certain overpressure in the cabin. Unfortunately, in practice, operators sometimes know how to perform treatments with the cabin door open and without applying personal protective equipment, which leads to damage to their health. Regular and high-quality measures of service and preventive maintenance are important factors for ensuring favourable working conditions regarding the protection of operators from dangerous substances by authors [15].

During operation, the operator must monitor the measuring and control instruments on the control panel in the tractor, the space in front, on the side and behind the tractor, and control the operation of the attachment device (with which the tractor is aggregated). On modern tractors, the glazed surfaces of the tractor cabin have been increased to the maximum in order to reduce the possibility of injuries during operation and to increase the visibility of the space in front, on the side and behind the tractor. The tractor is equipped with internal and external mirrors, lights and a device for washing and defrosting the windshield in order to work safely in the day and in the night. These structural solutions have reduced the invisible surfaces from the operator's workplace. Further development of agricultural tractor structures with the aim of improving visibility is focused on the application of cameras and sensors for the part of the space that is outside the operator's field of vision (blind spot). These systems detect a person who is in the tractor's trajectory, stop the tractor and thus prevent accidents by authors [26].

During operation, the tractor aggregates (tractor units) move on production surfaces on different reliefs (plains, smaller slopes and larger slopes). The best results of the operation of the tractor unit are achieved during operation on flat terrain, where we have good stability of the unit, less load on the tractor operator, lower fuel consumption, good efficiency of the unit, etc. Working on gentle inclines results in a decrease in the stability of the unit, an increased load on the operator, higher fuel consumption, a decrease in efficiency, etc. The worst results are achieved during the operation of the unit on higher slopes.

During rest and movement of tractor aggregates, the reaction values of the ground on the front and rear axles of the tractor also change, and their values are certainly affected by the ground on which the aggregate moves (flat surface, rise or slope), attachment tool or machine aggregated with the tractor. Although the tractor manufacturers have defined in their instructions the permitted slopes and climbs on which the tractors may move during operation, very often the tractor overturns and injures the operator. The most common reason for this is the neglect of this data due to the self-confidence of the operator ("I can do it, nothing will happen to me"), inexperience, the work of a minor or a person who occasionally drives the tractor, etc.

Due to their construction, tractors have a high center of gravity, which makes them unstable, and tractor overturning is the main factor in accidents by author [27].

In the Republic of Croatia, a safety cabin or safety frame is mandatory on all tractors registered for the first time after January 1, 1983 [28].

Very often, injuries during tractor operation occur:

- Due to the side overturning of the tractor or
- Longitudinal overturning of the tractor (ascent or slope).

The stability of the tractor is influenced by the following factors [15]:

- Linear tractor scale
- Magnitude, direction and direction of the forces acting on the tractor
- The slope of the ground and the direction of movement of the tractor (uphill or downhill).

Lateral overturning of a tractor moving on a slope, Fig. 2, will occur at the moment when the normal reaction of the ground at the point of the wheel that is in a higher position (the right wheel during the slope of the ground to the left side) is equal to zero (N1 = 0). Therefore, the beginning of the tractor overturning with regard to point 2 is at the moment when:

$$Gh_c \sin\alpha = 0{,}5G\,(B+b)\cos\alpha \quad (1)$$

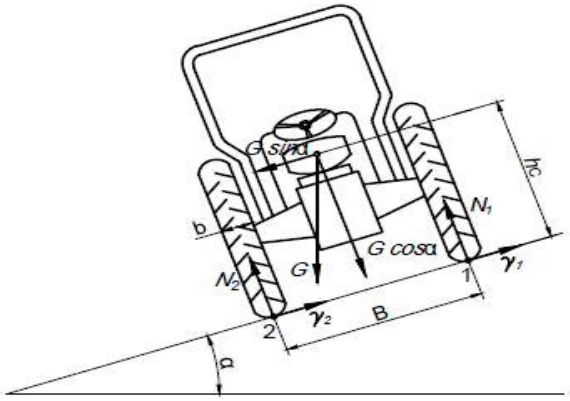


**Figure 2** Movement of the tractor on a side-sloping surface

Where: $G$ – tractor weight, N; $B$ – wheel spacing, m; $b$ – pneumatics width, m; $h_c$ – the height of the tractor's center of gravity, m; $\alpha$ – angle of inclination of the surface, °.

The tractor's side tipping can sometimes be preceded by the tractor's side drift. The values that influence the increase or decrease of the risk of lateral overturning are: the height of the tractor's center of gravity ($h_c$) and the sum ($b$+$b$) of the distance between the wheel spacing ($B$) and the wheel width ($b$). Smaller values of the height of the center of gravity ensure better stability of the tractor, as a larger sum ($B$+$b$).

When analyzing the longitudinal overturning of the tractor during operation, we distinguish between the overturning of the tractor around the axis of the rear wheels (during work on a climb), Fig. 3, and the overturning of the tractor around the axis of the front wheels (during work on a slope). The condition for overturning the tractor in the first case is the complete unloading of the front wheels ($N_p$ =0), that is, for the overturning of the tractor on the slope, the unloading of the rear wheels ($N_z$ = 0).

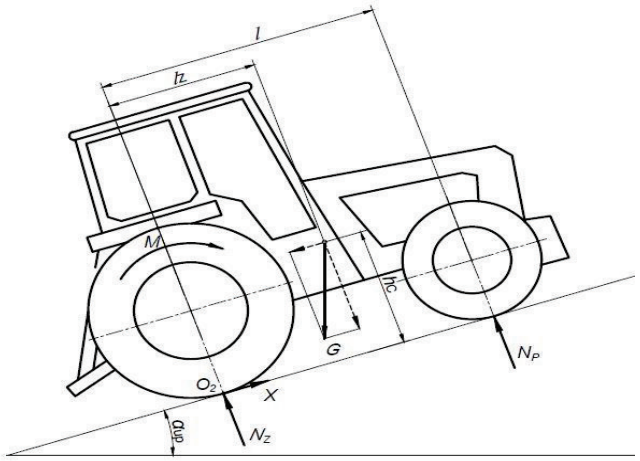


**Figure 3** Tractor on a slope

Where: $G$ – tractor weight, N; $h_c$ – the height of the tractor's center of gravity, m; $\alpha_{up}$ – angle of inclination of the surface, °; $l$ – distance between axles; $l_z$ – distance of the center of gravity from the axis of the rear wheel.

The stability of the tractor during standstill depends on the angle of inclination of the ascent or slope. Considering the position of the tractor's center of gravity, the limit angle when the tractor is at rest on the slope ($\alpha_p$) is greater than the limit angle of ascent (αup). For tractors with wheels, αup = 35-400, and $\alpha_p$ = 600 (it can be higher), according to the authors [15, 29]. Along with overturning, the longitudinal stability can also be hindered by the tractor sliding on the ground.

The loss of longitudinal stability can be the result of the tractor's drive wheels getting stuck, where they do not turn, which will result in the front part of the tractor being lifted off the ground and the tractor rotating around the rear (drive wheels).

Furthermore, the loss of longitudinal stability can occur due to an inadequate coupling height of the trailer and the tractor.

## 2 MATERIALS AND METHODS

Research regarding the safe work of agricultural tractor operators was carried out 2023 by surveying agricultural tractor operators in Osijek-Baranja and Vukovar-Srijem counties. The questionnaire contained eleven questions (Tab. 2). The results of the research have an indicative character since the answers were obtained by the subjective judgment of the respondents. The research carried out is part of the research that will be carried out in the counties of Eastern Croatia with regard to the safe work of operators.

**Table 2** Example of research survey

| No | Questions | Answers | |
|---|---|---|---|
| 1. | Are you familiar with working procedures that are considered safe? | Yes | No |
| 2. | Do you have technical documentation for all the machines you own? | Yes | No |
| 3. | Do you have a valid first aid kit in the tractor? | Yes | No |
| 4. | Do you follow the instructions for safe operation prescribed by the machine manufacturer? | Yes | No |
| 5. | I perform agrotechnical operations | Mostly alone (yes). | With another person (no). |
| 6. | In the event of an accident during work, are you able to provide professional first aid to the injured person? | Yes | No |
| 7. | During work I wear: | Work clothes and work footwear (yes). | Everyday clothes and everyday footwear (no). |
| 8. | Do you have the correct protection of all PTO shafts? | Yes | No |
| 9. | In the case of removal of plant residues and soil when the attachment machine becomes clogged: | I turn off the drive to the connecting machine (yes). | Turn off the drive machine (no). |
| 10. | Do you have a mobile device with you during work? | Yes | No |
| 11. | When carrying out repairs on carried machines that have been raised by a hydraulic lifting device: | Turn off the tractor and eliminate the fault (yes). | Turn off the tractor and place mats under the machine (no). |

The obtained results were processed using the Chi-Square Tests.

## 3 RESULTS AND DISCUSSION

The obtained results were analyzed and presented in two graphs.

Fig. 4 shows that most of the answers to the questions are positive, except for the answer to question 11 from the survey, where "no" indicates a good answer by looking at the survey. Furthermore, the analysis of the results found that operators in Osijek-Baranja County adhere to the measures necessary for safe work.

The analysis of the results of the Vukovar-Srijem County found that the answers to the questions were mostly positive, except for questions 3, 7 and 8 where the answer was "no" in the range of 55 % to 70 %. Furthermore, by looking at the survey, it was determined that the operators in the mentioned investigated county mostly do not have valid first aid in the tractor, do not wear work clothes and work footwear, and do not have proper protection of all PTO shafts (Fig. 5).

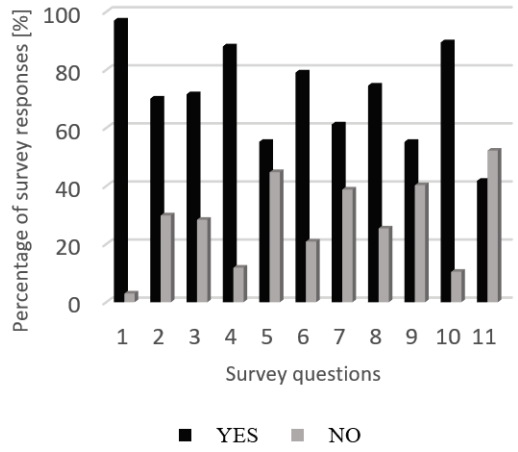


**Figure 4** Results of the safe work survey of the investigated Osijek-Baranja County

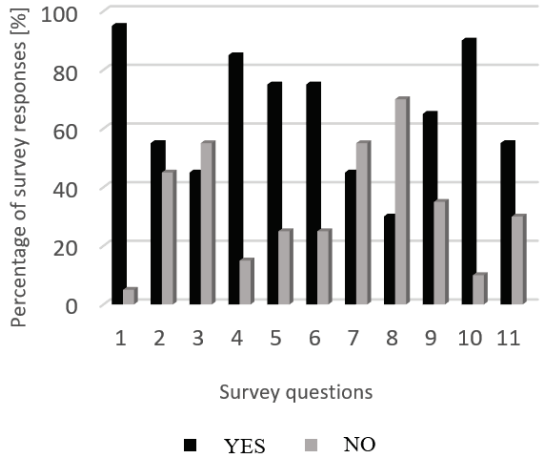


**Figure 5** Results of the safe work survey of the investigated Vukovar-Srijem County

By not complying with these measures, they put themselves at risk of minor injuries and serious life-threatening injuries, which is what the authors warn and refer to [1].

Operators should take a course or training on safe work in order to become aware and begin to comply with all measures until it is too late, as stated by the authors [2].

**Table 3** County and safety crosstabulation

| | | | Safety | | Total |
|---|---|---|---|---|---|
| | | | Positive | Negative | |
| County | OB | Count | 529 | 208 | 737 |
| | | Expected Count | 509 | 228 | 737 |
| | VS | Count | 132 | 88 | 220 |
| | | Expected Count | 152 | 68 | 220 |
| Total | | Count | 661 | 296 | 957 |
| | | Expected Count | 661 | 296 | 957 |
| OB - Osijek-Baranja County; VS - Vukovar-Srijem County | | | | | |

Tab. 3 shows that in Osijek-Baranja County were 529 positive answers regarding safety, with the corresponding theoretical frequency being 509, while for positive answers in Vukovar-Srijem County, the theoretical value (152) was higher than the actual value (132). Of the total number (957), there were over 69 % positive safety responses.

**Table 4** Chi-Square Tests

| | Value | df | Asymp. Sig. (2-sided) | Exact Sig. (2-sided) | Exact Sig. (1-sided) |
|---|---|---|---|---|---|
| Pearson Chi-Square | 11.001[a] | 1 | 0.001 | | |
| Continuity Correction[b] | 10.456 | 1 | 0.001 | | |
| Likelihood Ratio | 10.666 | 1 | 0.001 | | |
| Fisher's Exact Test | | | | 0.001 | 0.001 |
| *N* of Valid Cases | 957 | | | | |
| a. 0 cells (0,0 %) have expected count less than 5. The minimum expected count is 68.05.<br>b. Computed only for a 2×2 table | | | | | |

Value of the Chi-square test is 11.001 and shows high statistical significance (Tab. 4).

**Table 5** Symmetric Measures

| | | Value | Approx. Sig. |
|---|---|---|---|
| Nominal by Nominal | Phi | 0.107 | 0.001 |
| | Cramer's V | 0.107 | 0.001 |
| | Contingency Coefficient | 0.107 | 0.001 |
| *N* of Valid Cases | | 957 | |

Considering the values of coefficients in Tab. 5, it was concluded that the correlation of the variables is relatively low (0.107), but highly significant. It is possible to observe a trend of a lower number of safety-conscious operators in Vukovar-Srijem County, i.e. more safety-conscious operators in Osijek-Baranja County compared to the expected frequencies.

## 5 CONCLUSIONS

The specificity of agricultural production is manifested, among other things, by the movement of agricultural aggregates by production bases. Very often, operators of agricultural machinery perform their work alone in locations

far from populated areas. During work, the operator is exposed to numerous factors that negatively affect his safety and health, while the ergonomic solutions of modern agricultural machines strive to ensure the most favourable working conditions.

The conducted research indicates:

- That there is a difference between the investigated counties in terms of not having valid first aid, not wearing work clothes and work footwear, and the absence of PTO shaft protection;
- That not having a valid first aid kit reduces the quality of self-help provided by the operator in the event of an injury;
- That not wearing work clothes and work footwear reduces operator safety during work and increases the possibility of a negative impact on health;
- Due to the lack of protection of the cardan shaft, there is a great risk of minor, serious and life-threatening injuries;
- On the need for continuous education regarding safe work;
- Osijek-Baranja County operators are significantly aware of safety at work. In addition, there is a highly statistically significant relationship between the operators of a Particular County and safety at work.

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