

## Injuries sustained by victims of road accidents with the participation of farm tractors in mountainous regions

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*Received February 8.2013; accepted March 14.2013*

**Summary:** The paper presents the results of investigation of the consequences of accidents involving a farm tractor used in a mountainous region with a specific landform. The injuries sustained by victims of the accidents were analysed. The basis for analyses was the documentation prepared by the Agricultural Social Insurance Fund. The results of the analyses allowed for indicating the specificity of such accidents. The human body parts most exposed to damage and the severity of injuries were determined. The tractor drivers sustain the injuries of a different kind than the other participants of accidents (for example – the passengers). The drivers, apart from the upper and lower limbs injuries, sustain damage to head and trunk. Because of accidents, 2/3 of the victims sustain irreparable damage to the body. In majority, it is 1-5% of permanent damage to health. There are also fatal accidents.

**Key words:** tractor, accidents, injuries.

### INTRODUCTION

The principal element in agricultural engineering is a farm tractor. At present, in the fields of Poland, more than half a million of farm tractors of different types are in operation. They are used for typically agricultural works (tractor + unit) as well as in the transport (tractor + trailer). They are exploited under different conditions resulting from the specificity of agricultural lands where they are used.

In mountainous lands, because of steep slopes, the work of a tractor is difficult as it is necessary to keep its stability. Classic, traditionally designed farm tractors should be able to maintain their stability on a slope of 12°. Special constructions of mountain tractors are designed for working on the slopes of 25-30°. In Poland tractors of traditional designs are used in mountainous regions [5, 8, 11, 12].

The specificity of using tractors in mountainous lands, i.e. on steep slopes, involves the risk of accident if due caution is not observed, when a tractor working with a unit loses its transverse stability. Such accidents usually have considerable effects on mechanical damages of the tractor

and the units (or trailers) co-operating with it and on the accident participants [7, 18].

In order to identify and classify the injuries sustained by the persons participating in such accidents, an investigation was performed; the results of the investigation are discussed in this work.

### RESEARCH METHODOLOGY

The research included the accidents occurred in Lesser Poland/Małopolska Voivodeship, in the following counties: Limanowa, Nowy Sącz, Nowy Targ, Tatra. The structure of using lands in selected counties is presented in Table 1.

The analysis of the above table comparing the characteristics of examined counties shows that the part of the arable land in these counties amounts to 8% – 31,1%, of the orchards 1,5% – 3,8%, of meadows and pastures 7,4% – 16%, of forests and woodland 36% – 57%.

The accidents were analysed based on the documents of the Agricultural Social Insurance Fund (KRUS) from 2005 – 2010. According to its statute, KRUS keeps the documentation of all accidents that happened in agriculture. Therefore, the accident documentations gathered by KRUS can be used as source material for analysing accidents with the participation of farm tractors. In the paper, we used the materials from KRUS local post in Nowy Sącz, which activity includes the counties of Nowy Sącz, Limanowa, Tatra and Nowy Targ.

From the whole documentation, 46 accidents were selected. The authors assumed these accidents as a representative sample of the accidents with the participation of a farm tractor in the mountain region.

### RESEARCH RESULTS

The accidents occurred on the meadows and pastures area – 46%, on the dirt and forest roads – 25%, asphalt

**Table 1.** Structure of using lands in selected counties of Malopolska Voivodeship [10]

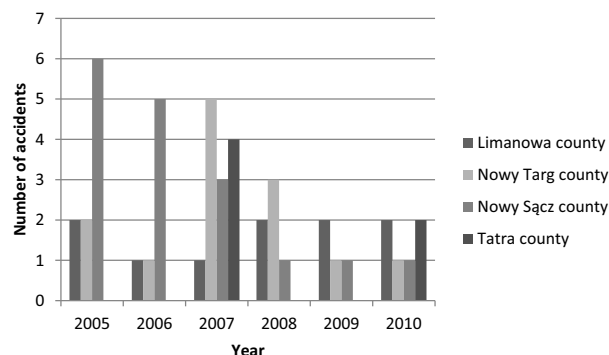
County	Total area [ha]	Arable lands [ha]					Forests and wood-land [ha]	Remained lands and waste land [ha]
		Total	Arable lands	Orchards	Meadows	Pastures		
Tatra	47162	14620	3772	1415	4716	4716	26882	5660
% of total	100	31	8	3	10	10	57	12
Nowy Targ	147466	72996	16221	2212	23594	30968	53088	21382
% of total	100	49,5	11	1,5	16	21	36	14,5
Limanowa	95196	49471	29596	3588	9256	7031	39161	6564
% of total	100	52	31,1	3,8	9,7	7,4	41,1	6,9
Nowy Sącz	155024	72322	36663	5924	16892	12843	69226	13476
% of total	100	46,7	23,6	3,8	10,9	8,3	44,7	8,7
Małopolska	1514410	880807	598159	22599	178406	81643	441642	191961
% of total	100	58,2	39,5	1,5	11,8	5,4	29,2	12,7

roads – 19%, other – 10%. The most frequently participating tractors were: URSUS C-330 – 44%, SAM (individually assembled tractors) – 24%, URSUS C-360 – 13%, others (URSUS, MF, Władymirec) – 19%. None of the farm tractors was a mountain tractor, adapted to work on a land with a steep slope.

The results of research are presented in diagrams. Because of the small sample size, the results give rather quality than quantity information.

The number of accidents in individual counties is presented in Fig. 1

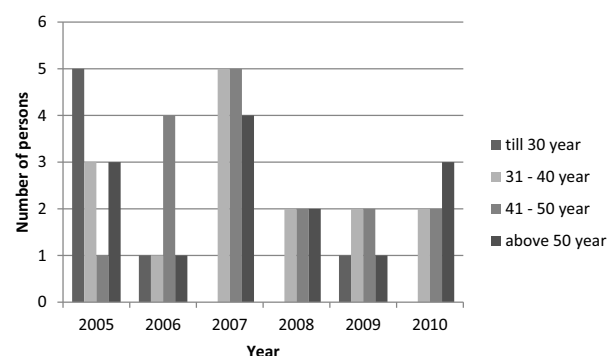
- Limanowa county – 10 accidents
- Nowy Targ county – 13 accidents
- Nowy Sącz county – 17 accidents
- Tatra county – 6 accidents

**Fig. 1.** Number of accidents with the participation of a tractor in individual counties

From the source material it appears that the number of accidents was the highest in Nowy Sącz county (17 accidents), and that it was the lowest in Tatra county (6 accidents). In Limanowa county, 10 accidents took place, while in Nowy Targ county – 13. It is clear that the number of accidents correlates with the surface development in these regions. In Nowy Sącz county, arable lands represent up to 46% of the county area, while in Tatra county only 31% of the county total area.

The most accidents with farm tractors in the mountainous lands happened in 2007 – 13 accidents, the least accidents happened in 2009 – only 4 accidents.

The results of the analysis of the accident participants age groups are presented in Fig. 2.

**Fig. 2.** Age groups of accident participants:

- above 51 years – 14 persons
- 50 – 41 years – 16 persons
- 40 – 31 years – 15 persons
- till 30 years – 7 persons

52 persons participated in 46 accidents. The analysis shows that in a majority of accidents, the participants were more than 31 years old (87%). The most numerous group, that is 28%, in mountainous regions includes the persons from the age interval 41 – 50. The group of people more than 51 years old is also large – 27% of all the participants of accidents with farm tractors. The persons younger than 30 constitute a small group of 7 persons, i.e. 17% of the total number of victims in such accidents. This age structure is presumably the effect of the advantageous opinion on abilities and routine of middle-aged and older people in the works using a farm tractor in mountainous regions. It is notable, at the same time, that the country 'grows old' and elderly people have health problems, which can influence the increase of the number of accidents in country lands.

In 2007, the accidents with the largest group of victims happened. In this period up to 14 persons participated in the accidents with farm tractors, ¼ of whom were the persons above 41 years old.

The analysis of the victims (driver, passenger, observer) of the accidents with farm tractors is presented in Fig. 3.

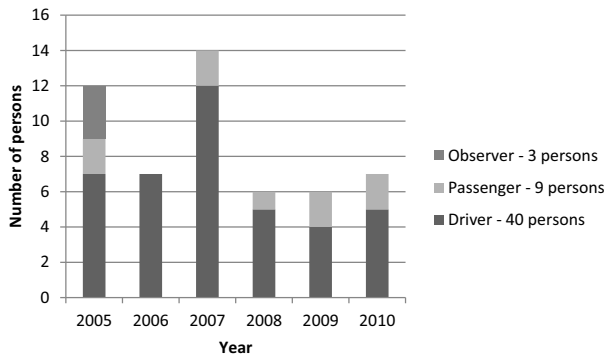


Fig. 3. Victims of agricultural accidents

The analysis shows that not only the persons actively participating in the works with a farm tractor: driver – 77% and passenger – 17%, but also passive observers of the event sustain injuries – 6 %.

Statistical participation of the victims of accidents with farm tractors is as follows: 0.23 passengers and 0.07 observers to one injured driver.

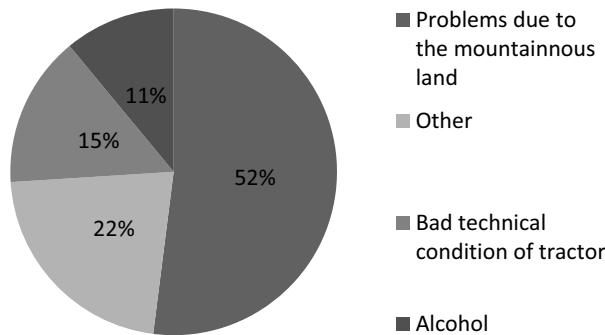


Fig. 4. Cause of accidents

The analysis of the accidents causes demonstrates that more than a half – 52% of accidents is caused by wrong driving technique, not adapted to the current conditions, and by insufficient driver abilities required for operating tractors under heavy mountainous conditions. Bad technical condition of the farm tractors contributes to an increase in the number of accidents, as well. Among 46 analysed accidents with a tractor, only 1/6 of all tractors had been tested. Alcohol and other causes like carelessness or gross negligence are the causes of 1/3 accidents with farm tractors.

The operation of a farm tractor in a mountainous region needs knowing, experience, good equipment and perceptiveness as well as full concentration, because it often happens that some little error involves heavy accidents and injuries. The best solution for the work in mountainous regions is a mountain tractor, which by its design and technology increases the safety and facilitates the work.

INJURIES OF ACCIDENT PARTICIPANTS

It results from the analysis of injuries severity of the victims of accidents with the participation of farm tractors, that within a period of 6 years (2005 – 2010), 50% of victims (27 persons) sustained constant, irreversible damage to health,

16 people sustained prolonged injuries and 8 persons died. Moreover, the attention must be paid to the severity degree of prolonged and constant injuries. The severity of prolonged damages to health, i.e. the percentage of damage to health, is significantly lesser than in the case of constant injuries. From the group of 52 persons, half of them will be disabled for life. The scale of danger involved in the work using a tractor in the regions with significant slopes is very large.

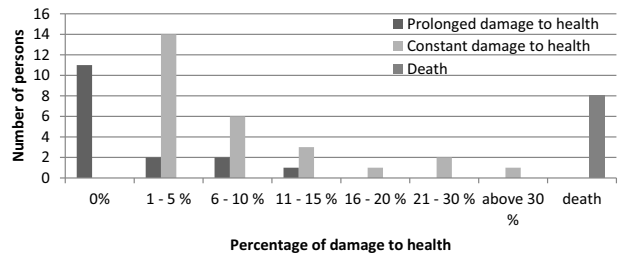


Fig. 5. Injury severity rate of the victims

The location of the post-accident injuries is presented in Fig. 6

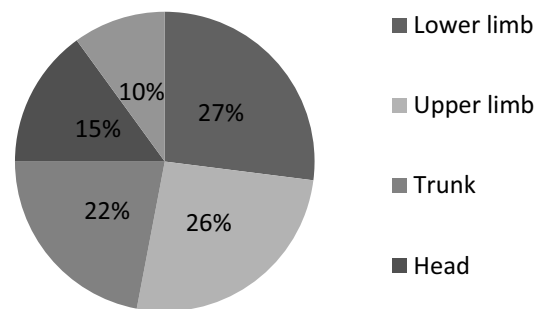


Fig. 6. Location of post-accident injuries

The analysis of the post-accident injuries shows that half of them are the injuries to the limbs: upper (26%) and lower (27%). Trunk injuries are 1/4 of all the injuries. Head injuries and multiple-organ injuries are seldom encountered; they represent 25% of all post-accident injuries.

A comparison of injuries sustained by a driver and a passenger is presented in Fig. 7

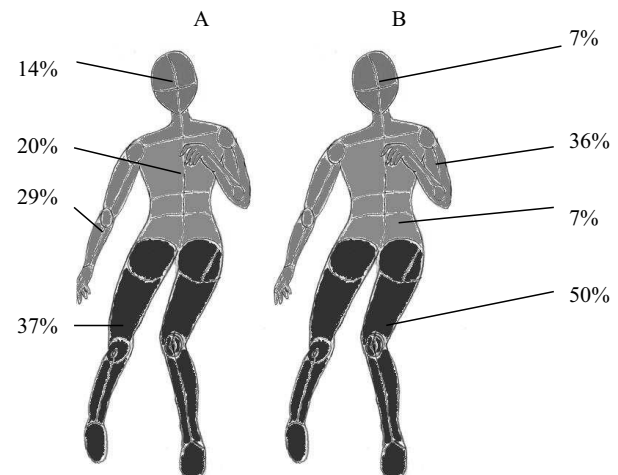


Fig. 7. Comparison of injury location in accident victims: A – driver, B – passenger

It results from the analysis of post-accident injury location in a driver and in a passenger, that the passenger mostly sustains the injuries to a lower limb (50% of all injuries) and to an upper limb (36%). Drivers are often hurt in upper and lower limbs. However, a comparative analysis demonstrates a difference in location of the remaining post-accident injuries; 1/5 injuries of drivers are damages to trunk, a passenger suffers such injuries twice less. It is similar in the case of head injuries – a driver suffers such injuries twice more often than a passenger.

The post-accident injuries to upper (Fig. 8) and lower (Fig. 9) limbs were analysed in detail.

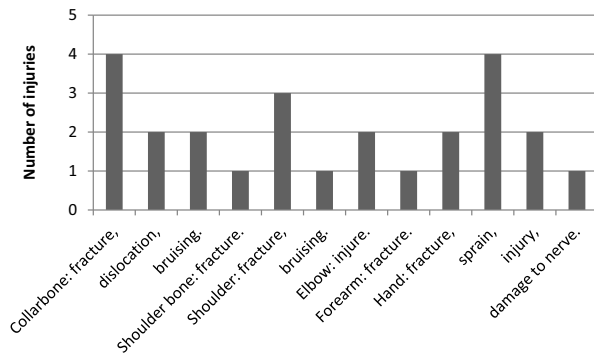


Fig. 8. Post-accident injuries to upper limbs

The analysis shows that 1/3 of all upper limb injuries are the damages to the upper limb pectoral girdle, and 2/3 are the injuries to the upper limb self. The most frequent injury as a result of accidents with a farm tractor in a mountainous region is collarbone fracture and sprain of hand as well as fracture within the shoulder. The most frequent injury is fracture – 45% of injuries, and less serious ones – bruise and damage to the upper limb – constitute 30% of injuries.

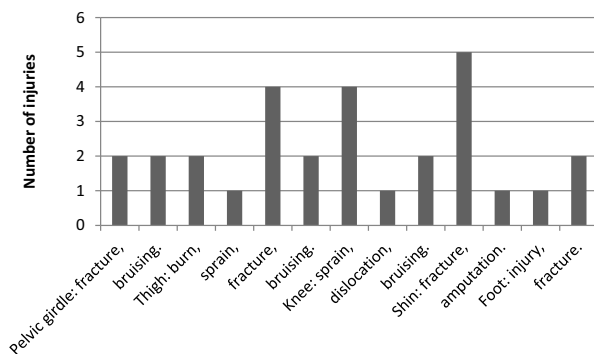


Fig. 9. Post-accident injuries to lower limbs

The analysis of the injuries to a lower limb shows that 86% of injuries were the injuries of the limb itself; other 14% are the injuries to the pelvic girdle. Mostly, as a result of accidents, damages to thigh follow – they constitute 1/3 of all the injuries – next are damages to knee and shank (shin). The most common is the fracture of shin, knee sprain and fracture of thigh. Fracture is the most common injury to a lower limb. It happens in almost half of cases.

Decisive for the extensiveness of injuries are the following factors: place, surface and energy of the vehicle impulse contact between the tractor and the victim. Furthermore,

it is notable that the extensiveness as well as the quality of injuries would be dependent on the physical condition (properties) of a particular person. It depends, among other things, on the features like bone and soft tissue elasticity, i.e. damping capacity and energy dissipation [2, 6, 17].

Determinants of the injury type are the kind of the collision, the position occupied by the person and the safety measures used by this person, like safety cabin, safety belts [3, 4, 16, 19].

The collected and analysed source material proves that the most common location of injuries occurring in both tractor drivers and passengers is a lower limb. The type of injury most commonly sustained by the victims is fracture.

Fracture is a break of bone continuity on its whole cross section. It happens under the action of an external force applied to the bone. These forces act on the bone until the moment of surpassing the allowable stress causing destructive deformations – crack and fracture of the bone.

The mechanism of the fracture depends on the position and direction of the force causing the injury. There are two principal mechanisms: direct – when the injury force acts directly on the bone, and indirect – when the injury force acts through another bone, articulation, tendon etc. [6, 15].

In the case of the accidents with a tractor, 2/3 victims are the drivers. The injury type is determined by the accident run, the position occupied by the particular person, as well as the safety measures used by this person, like safety cabin, safety belts.

## CONCLUSIONS

- The number of accidents within a representative sample from a mountainous region correlates with the region's development.
- More than 50% of accidents are caused by wrong driving technique, not adapted to the working conditions in a mountainous region and by problems connected with agriculture.
- The injured are mostly (80% of accidents) the drivers. The passengers participate in every fifth accident, and the observers constitute 6% of the injured. The largest age group affected are people after 41 years of age. The 'ageing agriculture', both in terms of technology and humans, influences the increase of the number of accidents.
- In the accidents, the injured drivers and passengers sustain different kind of damages. The passengers are more exposed to the injuries of lower and upper limbs, which may be connected with jumping down the tractor during the accidents. The drivers sustain damages to lower and upper limbs as well, but they are exposed almost as often to head and trunk injuries.
- In the accidents, half of victims sustain irreparable damage to the body, though the severity of these injuries usually is not significant (the largest group within 1% – 5% of permanent damage to health), however a farmer with a leg or hand motor disability would have trouble performing his duties.

- The work with a farm tractor in a mountainous region requires knowledge, experience, good equipment as well as perceptiveness and full concentration on the performed task, because it often happens that some small error or an oversight results in heavy accidents. The best solution for the work in mountainous regions is a mountain tractor, which by its design and technology increases the safety and facilitates the work.

## REFERENCES

1. **Będziński R.: 1997**, Biomechanika inżynierska, Oficyna Wydawnicza Politechniki Wrocławskiej, Wrocław.
2. **Błaszczak J.: 2004**, Biomechanika kliniczna, Wydawnictwo PZWL, Warszawa.
3. **Bocheński C., Klimkiewicz M.: 1987**, Bezpieczeństwo maszyn rolniczych w ruchu drogowym, Przegląd Techniki Rolniczej i Leśnej nr 10.
4. **Cieź J.: 1998**, Problemy ergonomii i bezpieczeństwa pracy w sezonowym użytkowaniu urządzeń technicznych w rolnictwie, Prace Komisji Nauk Rolniczych PAN tom 1.
5. **Dajniak H.: 1985**, Ciągniki – teoria ruchu i konstruowanie, WKiŁ Warszawa.
6. **Dziak A., Sanders R.: 2008**, Traumatologia układu ruchu, Elsevier Urban & Partner.
7. **Ekielski A., Skrobacki A.: 2006**, Pojazdy i ciągniki rolnicze, Wieś Jutra.
8. **Gadomski W., Mróz S.: 1983**, Ciągniki rolnicze, Wydawnictwo WSiP, Warszawa.
9. **Krasowska A.: 2012**, Analiza obrażeń rolników powstałych w czasie wypadków z udziałem ciągników rolniczych na terenach górskich, Praca dyplomowa inżynierska, Politechnika Krakowska Wydział Mechaniczny.
10. **Kondracki J.: 2009**, Geografia regionalna Polski, Wydawnictwo PWN, Warszawa.
11. **Kruszewski Z., Michalak G.: 1989**, Wybrane zagadnienia z teorii ruchu oraz budowy pojazdów rolniczych, Wydawnictwo Politechniki Warszawskiej, Warszawa.
12. **Nowacki T.: 1963**, Ciągniki rolnicze i samochody, Państwowe Wydawnictwo Rolnicze i Leśne, Warszawa.
13. **Pike J. A.: 1990**, Automotive safety – Anatomy, injury, testing and regulation, Society of Automotive Engineers.
14. **Szeląg Sikora A.: 2012**, Regional differences in equipment of machinery park on farms, TeKa Commission of Motorization and Energetics in Agriculture, vol. 12.
15. **Thompson J. C.: 2007**, Atlas anatomii ortopedycznej Nettera, Elsevier Urban & Partner.
16. **Wicher J.: 2006**, Bezpieczeństwo samochodów i ruchu drogowego, Wydawnictwo WKiŁ, Warszawa.
17. **Wismans J. S. i inni: 1994**, Injury biomechanics, Eindhoven University of Technology.
18. **Woźniak W.: 2005**, Ciągniki i maszyny rolnicze – Budowa i przeznaczenie, Wydawnictwo Przemysłowego Instytutu Maszyn Rolniczych, Poznań.
19. **Zalewski P.: 1994**, Bezpieczeństwo kierowcy ciągnika na zbożu jako problem ergonomiczny, Zeszyty Problemowe Postępów Nauk Rolniczych PAN tom 415.

OBRAŻENIA OSÓB W WYPADKACH  
Z UDZIAŁEM CIĄGNIKÓW ROLNICZYCH  
NA OBSZARZE GÓRSKIM

**Streszczenie.** W pracy przedstawiono wyniki badań skutków wypadków z udziałem ciągnika rolniczego eksploatowanego w specyficznym pod względem ukształtowania terenie górskim. Analizowano obrażenia jakich doznały osoby uczestniczące w wypadkach. Podstawą do przeprowadzonych analiz była dokumentacja wypadków prowadzona przez Kasy Rolniczego Ubezpieczenia Społecznego. Wyniki analizy pozwoliły na wskazanie specyfiki takich wypadków. Określono jakie części ciała człowieka są najbardziej narażone na obrażenia oraz ciężkość tych obrażeń. Kierujący ciągnikiem ulegają obrażeniom innego typu niż pozostali uczestnicy wypadku (np. pasażerowie). Kierowcy, obok obrażeń kończyn dolnych i górnych, doznają obrażeń głowy i tułowia. W wyniku wypadków 2/3 poszkodowanych ulega stałemu nieodwracalnemu uszkodzeniu ciała. W większości jest to 1%-5% stałego uszczerbku na zdrowiu. Zdarzają się także wypadki ze skutkiem śmiertelnym.

**Słowa kluczowe:** ciągnik rolniczy, wypadek, obrażenia.

The study was performed within the framework of a PK WM M-4/84/2013/DS Project.

