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

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Abstract. Above all between 2020 and 2022, a large part of the population of our planet was terribly affected by the COVID pandemic, causing millions of victims. The people habits and lifestyles were deeply changed, also as regards work, with a high increase of remote-working. This upheaval slightly affected the agricultural activity that was, is and will be always strictly linked to natural cycles and to the passing of the seasons. In the developed countries the agricultural activity is frequently based on part-time workers; thus, the manpower engagement could be evolved during the pandemic, especially in the lock-down periods. The forced closure of industrial and service sectors lead to a longer time possibly devoted to other activities, with a temporary increase of labour carried out by people not highly skilled in using agricultural machinery. Thus, also the most dangerous related risk factor, i.e. the tractor overturning, could have registered an increase. To properly investigate this possible trend, the independent observatory established since 2008 at DISAA-UNIMI on tractor overturning accidents in Italy, compared the data coming from the period 2008-2019 with those concerning the pandemic period. In 2021 and 2022 the number of fatal tractor overturning did not fall outside the consolidated range of previous period (approx. 100 to 140 fatalities), but in 2020 a significant decrease was recorded. Moreover, during all the pandemic period the average age of the victims decreased, so confirming a more intense working activity of younger operators, probably temporarily engaged in the COVID lock-down time.

Keywords: COVID, tractor overturning, fatal accidents, manpower

1 Introduction

1.1 Tractor stability

The agricultural sector has always disputed the construction sector for the sad record of fatal accidents. The issue of occupational safety in agriculture is a global concern, with the majority of accidents associated with the tractors operation, particularly involving overturning. In Italy, some agricultural chains, such as viticulture, are commonly cultivated on sloping terrain. Tractors often encounter stability challenges when maneuvering at the headlands. Several studies have been conducted to assess tractor stability in various scenarios, aiming to gain a better understanding of how overturning

accidents occur. Franceschetti et al. [1] developed a kinematic model, to calculate lateral stability angle for articulated tractors. Carabin at al. [2] built a vehicle test bench to determine the stability of agricultural machinery travelling on sloping terrain. Franceschetti et al. [3] compared different ROPS, a cab and 2-post front-mounted tiltable rollbar, ascertaining that on sloping terrain narrow-track tractors equipped with cab have worse stability performance. The vagueness of certain standard procedures relating to ROPS tests has been examined and discussed [4] to develop and possibly update existing regulations.

1.2 Tractor overturning and risk reduction

Overturning occurs especially on sloping ground, during wrong manoeuvres or due to improper coupling and use of implements. In this scenario, the use of narrow-track tractors without ROPS or with tiltable protective structure in rest (horizontal) position increases the risk of severe and sometime fatal accidents [5]. Altough not all overturning accidents have a fatal outcome, it is certain that fatalities are given high media attention. At the DiSAA independent observatory, Facchinetti et al. [6] carefully have analyzed from 2008 to 2019 1414 tractor overturning accidents in Italy, recovering the data from many web portals of news, averaging 100 to 140 fatalities per year. INAIL (National Institute for Insurance Against Accidents at Work) recorded in Italy 788 fatal accidents in agriculture from 2015 to 2019 [7]; most of them were fatal overturning of tractors. In 2010 in USA, it has been estimated that 800 people died in accidents involving tractors, more than half of them for overturning [8]. A study conducted in Canada (Saskatchewan) in the period 2005-2019 registered 166 victims involved in work accidents in agriculture; most of these were due to tractor overturning. Moreover, in 15 years a non-significant decrease trend in death rate was recorded [9]. Also in Turkey fatal accidents in agriculture were analysed from 1992 to 2016: 49.5% of these involved overturning tractors [10]. A study conducted between 1997 and 2002 in West Virginia (USA) revealed that 75% of fatal accidents are caused by tractor overturning [11]. Also in Spain, Jaren et al. found a very high number of fatal agricultural accident in Spain from 2010 to 2019 [12]. Researchers proposed several solutions to this important problem: Caffaro at al. explored factors that can prevent an accident, such as training activities, involvement of older farmers in mentoring activities and accident history [13]. Obviously the introduction of policies to promote safety at work in agriculture can make the difference. In fact, many American States do not effectively promote the use of ROPS, despite the countless deaths by tractor overturning [14]. Differently, the Swedish approach aimed at preventing fatal and non-fatal accidents arising from tractor overturning, achieved through the installation of ROPS on new tractors, has proven to be successful. In 30 years, deaths fallen down from 12 to 0.2 per 100,000 agricultural tractors; over the same period, total number of Swedish agricultural tractors grew almost 300 %, and the tractors equipped with ROPS increased to approximately 90% [15]. More technical solutions have also been proposed to promote the correct use of the rollbar. To facilitate the lifting of the rear-mounted foldable roll-bar, Micheletti Cremasco at al. [16] designed a dipstick to be used by an operator standing on the ground. Gattamelata et al. [17] designed and tested virtually a new foldable 2-post rear rollbar, based on 3 sections controlled by a four-bar kinematic

solution. Other studies focused on the development of automatically extendable protective structures for agricultural tractors: Ojados-Gonzalez et al. [18] developed HydraROPS, a system using hydraulic power and raising tiltable ROPS either manually by the driver or automatically during an overturning event. A similar system, for lowering/raising tiltable ROPS (Roll-Over Protective Structure) using a linear electric actuator has been designed by Gattamelata et al. [19], equipped with an automatic device to safely and automatically lock the rollbar. Rui et al. [20] use a series of sensors and a web application to prevent accidents considering the characteristics of agricultural terrain. After having defining the location of the clearance zone around the driver's seat and steering wheel, Pessina et al. [21] examined the elastic and plastic deformation values of the ROPS, defining criteria for an accurate and effective design and manufacturing.

1.3 COVID pandemic influence

Above all between 2020 and 2022, a large part of the population of our planet was devastated by the terrible COVID pandemic, causing millions of victims. For more or less time, habits and lifestyles of the people were deeply changed, also as regards work, with a high increase of remote work. This upheaval did not affected, if not indirectly, the agricultural activity that was, is and will be always strictly linked to natural cycles, that is to crops production, livestock farming, forestry activities and of course to the succession of seasons. The closure of country borders, cities lockdowns and restrictions on movement have increased awareness regarding the significance of ensuring food availability for citizens. This has led to an increase in costs, particularly for vegetables and perishable goods [22]. This paper is focused on the study of fatal tractor overturning accidents in the period of the COVID-19 pandemic (2020-2022), compared with the previous years (2008-2019), analysing possible (negative or positive) impacts on the trend.

2 Materials and method

The independent observatory established at DISAA-UNIMI from 2008 investigated tractor overturning accidents in Italy through the data available in a high number of web sites and portals (examples encompass “Associazione Sostenitori Amici della Polizia Stradale”, www.asaps.it, as well as the online platforms of periodicals and daily newspapers with nationwide, regional, and local dissemination), with the aim to extract maximum information. These data were implemented and compared with statistics on agricultural land, manpower and tractors use. The results concerning the period 2008-2019 were so compared with those concerning the pandemic years 2020, 2021 and 2022. Accessing to the most popular search engines, a database was built considering specific keywords, such as "dead-tractor”, “tractor fatal accident” and “tractor overturning”. The results were then classified based on the publication date of the news, and fatal overturning accidents were categorized using various criteria, as follows: date (year, month and day), site (region, province and municipality), driver (gender, age and

nationality), passenger (number), activity (field task and road transfer), tractor characteristics (wheeled and crawler) and ROPS type.

3 Results and discussion

In the period 2008-2019 the tractor fatal accidents ranged yearly from 102 to 145 events. A significant decrease was recorded in 2020 (83 fatalities only), in correspondence to the first COVID pandemic wave. Unfortunately, in the subsequent years (2021 and 2022) the accidents number came again within the range detected previously (121 and 123 events respectively, figure 1).

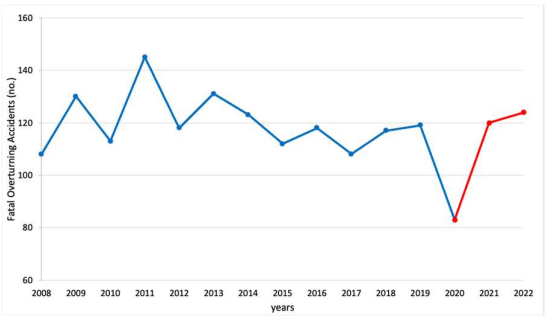

Fig. 1. Trend of tractors fatal overturning accidents from 2008 to 2022.

The trend of fatal overturning accident in 2020 significantly deviates from the pre-COVID period average. As expected, the majority of accidents is occurring in the spring and summer months (from April to September), when the field work is more intense (figure 2). This trend was different in 2020, when in particular in the periods March-June and September less remarkable increases were detected, probably due to generalized reduction of the labour activity for the lock-down occurred in Italy in these two first COVID waves. Numbers in 2021 exceeded those of pre-COVID average, excluded July and October data. The trend in 2022 is comparable to the pre-COVID average, indicating a gradual return to normality, despite local short lock-down periods. Figure 3 shows overturning fatalities from 2008 to 2022, classified with reference to the days of the week. The data suggests that there is minimal variability across all seven days, not confirming the hypothesis that physical and mental fatigue accumulated from Monday to Friday leads to a fall of the attention level, and subsequently a higher number of accidents in the weekend. On the other hand, unlike industrial work the agricultural activity is distributed along the entire week (included Saturday and Sunday), and similarly accidents occur. Moreover, non-professional workers increase their activity during the weekend, so contributing to the occurrence of serious (and unfortunately also fatal) accidents. The splitting of fatal events by day of the week in each year surveyed (figure 4), highlighted that in 2020 there was a clear drop in victims number, especially on Sunday and Saturday.

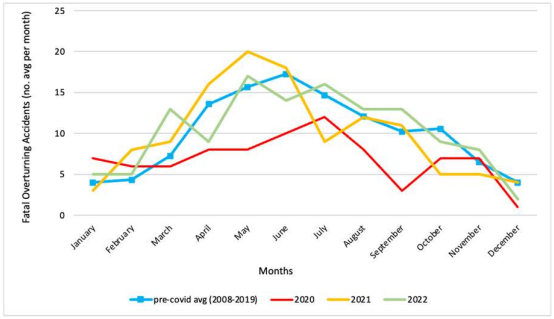

Fig. 2. Comparison of fatal overturning accidents between average 2008-2019 (pre-COVID period) and the years 2020, 2021 and 2022.

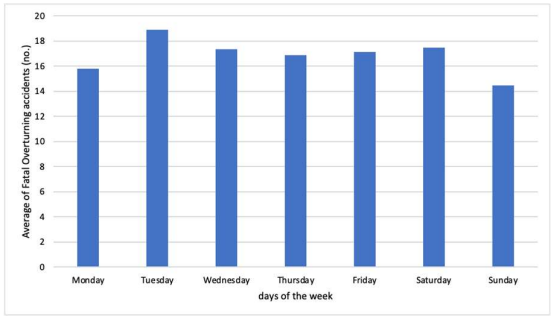

Fig. 3. Average of overturning fatalities recorded in 2008-2022, with reference to the day of the week.

This is probably why in that year only professional workers worked in the weekend, while non-professional, stayed at home, thus reducing the number of fatalities.

An other worrying factor to be taken into account is the high average age of Italian farmers, exceeding 65; for this, an increasing number of victims is expectable in older people classes, also due to the unfavorable combination "old farmer + old (and so often unsafe) tractor". Classifying fatalities according macro-age class (of 20 years, as shown in Figure 5), in 2020 the group over 61 experienced a significant drop in fatal overturning, decreasing from an annual average of 70 cases before the COVID-19 pandemic to 44 cases. However, this number rapidly raised again in 2021 and returned to pre-pandemic level in 2022. One of the possible reasons of the older victims decrease for tractor overturning is the heavy illness (up to death) due to the COVID pandemic.

This trend appears confirmed also in the 41-60 class: the average dropped from 34 in the period 2008-2019 to 21 in 2020. On the contrary, younger farmers (21-40 years old) involved in fatal accidents were not decreasing in the surveyed years.

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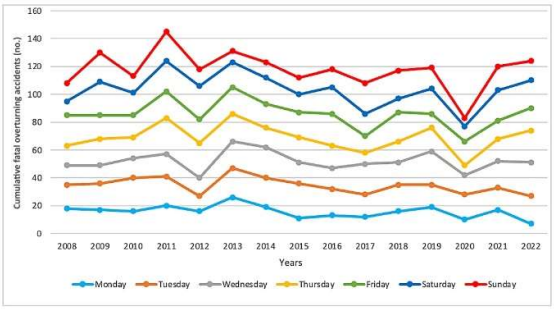

Fig. 4. Trend of overturning fatalities (2008-2022) by weekday

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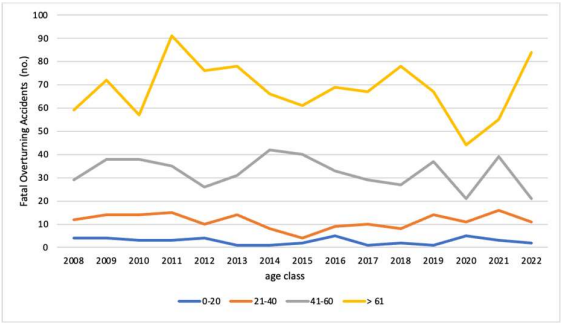

Fig. 5. Trend of fatalities for tractor overturning (2008-2022) classified per macro-age class.

The COVID period did not lead to differences in the gender and nationality of farmers involved in fatal accidents. Throughout the entire period analysed (2008-2022), 98.6% of the accidents involved men, compared to 1.4% involving women, numbers in line with the gender distribution of the employees in agriculture. Furthermore, 95% of the people involved in fatal accidents had Italian nationality, while only 4% were coming from non EU countries.

For a more refined survey, the absolute number of fatal accidents should be compared with other parameters involved in agricultural mechanization. On a regional level and for the entire period surveyed, the frequency of tractor fatal overturning per hours worked evidenced a high figure for Abruzzo (more than 1.2 fatalities per million hours worked), and then for Liguria, Molise, Tuscany and Umbria, with about 0.8 fatal events

per million hours worked (figure 6). The rugged sloping terrain combined with an old and worn tractor fleet seems to be the main reason of the trend found in these regions.

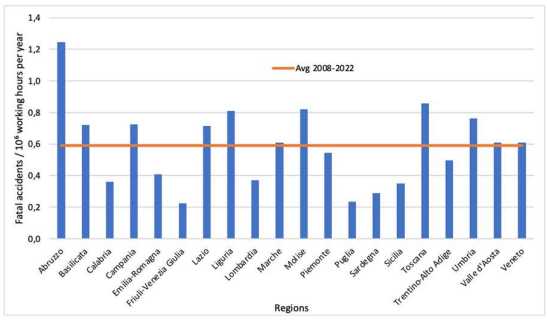

Fig. 6. Frequency of the accidents per working time.

Considering the UAA (figure 7), the Liguria highlights an accidents frequency (almost 6 fatalities per 100.000 ha) roughly 5 times higher than the national average (1.2 fatal accidents per 100.000 ha). Apart again the rugged and sloped terrain, this is probably due to the limited extension of UAA in Liguria, being very popular the protected installations (greenhouses, tunnels, etc.).

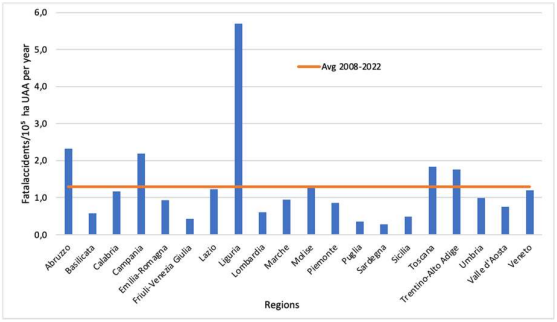

Fig. 7. Frequency of the accidents per UAA (Utilizable Agricultural Area).

In 54% of the cases the tractors did not have any ROPS; moreover, 19 % of the tractors involved in a fatal accident were fitted with two post front-mounted tiltable roll-bar, that at the time of the fatal event was in horizontal position, so not assuring any protection. These are the most critical situations found by time; several efforts have been made in recent years to improve these situations, such as issuing guidelines for retrofitting ROPS suitable for used tractors [23] and developing several information campaigns.
Moreover, in 2012 came in force in Italy the obligation of a specific professional qualification for driving tractors and other self-propelled machinery. The coming in force of this provision resulted in an initial positive effect in subsequent years, where a significant number of used tractors were equipped with a ROPS in retrofitting and at the

same time farmers were adequately informed about the overturning risks (figure 8). Unfortunately, since 2016 the number of overturning accidents recording in these two critical situations came back to pre-2012 numbers, so nullifying the positive effects.

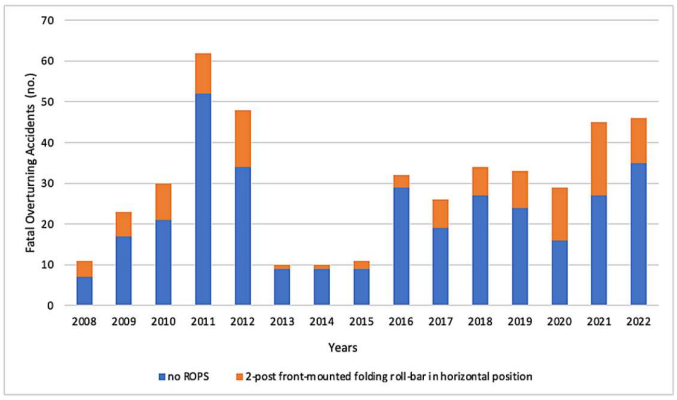

Fig. 8. Trend of fatal overturning accidents (2008-2022) per ROPS type

The COVID period did not modified the situation.

4. Conclusions

The strengths inherent in the approach outlined in this study include minimized resource commitment, a satisfactory level of approximation, and, most significantly, unparalleled timeliness in accident monitoring. However, the study shows some weaknesses: the statistics could not completely reflect reality, for example because some fatal events could be missed, the detail level of the events should be not completely congruent, such as the working position of the victims, professional or non-professionals and also the news may sometimes suffer from the press inaccuracies.

In any case, the main outstanding coming out from this survey are that the COVID pandemic affected significantly the agricultural activity, but only in the first lock-down period (in Italy, March-May 2020). As a consequence, also the tractor fatal overturning accidents decreased in comparison in the same period. Notwithstanding further restrictions due to the same reason, in the subsequent years 2021 and 2022 the number of fatalities (121 and 123 events respectively) sadly came back very close to the average of the previous period. During the pandemic period, a decrease of the older victims for tractor overturning was really detected, due probably to a reduced labour amount of these age classes, but this data was not confirmed in 2021 and 2022.

More in general, in these last 10-12 years some actions devoted to resolve critical situations have been studied and settled up, and others are under development, such as the obligation of a specific professional qualification for driving tractors and other self-propelled machinery in 2012, and their periodical check in 2015. Indeed, this last action

is not yet in force, due to the lack of a regulation for the activation of the service. At the same time, some researchers studied different solutions to contribute in solving the most critical situations, such as compact ROPS, the TRACLAS project [24] and QROPS [25].

References

1. Franceschetti, B., Rondelli, V., Capacci, E.: Lateral Stability Performance of Articulated Narrow-Track Tractors. In Agronomy 11, no. 12: 2512 (2021). https://doi.org/10.3390/agronomy11122512
2. Carabin, G., Becce, L., Mazzetto, F.: Development and Experimental Evaluation of a Tractor Roll-Over Stability Model. In: Ferro, V., Giordano, G., Orlando, S., Vallone, M., Cascone, G., Porto, S.M.C. (eds) AIIA 2022: Biosystems Engineering Towards the Green Deal. AIIA 2022. Lecture Notes in Civil Engineering, vol 337. Springer, Cham (2023)
3. Franceschetti, B., Rondelli, V., Ciuffoli, A.: Comparing the Influence of Roll-Over Protective Structure Type on Tractor Lateral Stability. Safety Science, Volume 115, June 2019, Pages 42-50 (2019). https://doi.org/10.1016/j.ssci.2019.01.028
4. Guzzomi, A. L., Rondelli, V., Capacci, E.: Operator Protection in Rollover Events of Articulated Narrow Track Tractors. Biosystems Engineering, Volume 185, September 2019, Pages 103-115 (2019). https://doi.org/10.1016/j.biosystemseng.2019.04.020
5. Gattamelata, D., Vita, L., Fargnoli, M.: Machinery safety and ergonomics: A case study research to augment agricultural tracklaying tractors' safety and usability. Safety and Usability. Int J Environ Res Public Health. 2021 Aug 16; 18 (16): 8643 (2021). https://doi.org/10.3390/ijerph18168643. PMID: 34444390; PMCID: PMC8393415.
6. Facchinetti D., Santoro S., Galli L. E., Pessina D.: Agricultural Tractor Roll-Over Related Fatalities in Italy: Results from a 12 Years Analysis. Sustainability 2021, 13, 4536 (2021). https://doi.org/10.3390/su13084536
7. INAIL. Banca Dati Statistica. Available online: https://bancadaticsa.inail.it/bancadaticsa/login.asp (accessed on 8th April 2021).
8. Abubakar, M.S., Ahmad, D., & Akande, F.B.: A Review of Farm Tractor Overturning Accidents and Safety. Pertanika Journal of Science and Technology, 18, 377-385 (2010).
9. Karunanayake, C., P., Koehncke, N., Enebeli, S., Ulmer, K., Rennie, D. C.: Trends in Work-Related Fatal Farm Injuries, Saskatchewan, Canada: 2005–2019. Journal of Agromedicine, volume 28, 2023 – issue 3, Pages 444-455, Published online: 05 Nov (2022). https://doi.org/10.1080/1059924X.2022.2134244
10. Karbeyaz, K., Şimşek, Ü., Yilmaz, A.: Deaths Related to Tractor Accidents in Eskişehir, Turkey: A 25-Year Analysis; J Forensic Sci. 2019 Nov, 64(6): 1731-1734 (2019). https://doi.org/10.1111/1556-4029.14102. Epub 2019 Jun 4. PMID: 31162682.
11. Helmkamp, J., Lundstrom, W.: #56 Tractor-related deaths among west virginia farmers. Annals of Epidemiology, 12, 510 (2002). https://doi.org/10.1016/S1047-2797(02)00344-7.
12. Jarén, C., Ibarrola, A., Mangado, T., Adin, A., Arnal, P., López-Maestresalas, A., Ríos, A., Arazuri, S.: Fatal Tractor Accidents in the Agricultural Sector in Spain during the Past Decade. Agronomy 2022, 12(7), 1694 (2022). https://doi.org/10.3390/agronomy12071694
13. Caffaro, F., Roccato, M., De Paolis, G., Micheletti Cremasco, M., Cavallo, E.: Promoting farming sustainability: The effects of age, training, history of accidents and social-psychological variables on the adoption of on-farm safety behaviors. Journal of Safety Research, Volume 80, February 2022, Pages 371-379 (2022). https://doi.org/10.1016/j.jsr.2021.12.018
14. Sorensen, J.A., Milkovich, P.J., Dorfman, L., Mejia, P., Perez-Sanz, S.B.: ROPS commentary - Addressing our fatal blind spot: Applying evidence - based solutions to reduce the most

frequent cause of death on U.S. farms. American Journal of Industrial Medicine. Volume66, Issue7, July 2023, Pages 554-557, (2022). https://doi.org/10.1002/ajim.23484

15. Springfeldt, B., Thorson, J.: Sweden's Thirty-year Experience with Tractor Rollovers. Journal of Agricultural Safety and Health 4(3):173-180. (1998). https://doi.org/10.13031/2013.15355
16. Micheletti Cremasco, M., Vigoroso, L., Caffaro, F., Paletto, G., Cavallo, E.: Considering human variability in the design of safe interaction with agricultural machinery: The case of foldable roll-over protective structure (FROPS) manual handling. Agronomy, 11 (7), art. No. 1303 (2021). (https://doi.org/10.3390/agronomy11071303)
17. Gattamelata, D., Laurendi, V., Vita L., Galli L.E., Pessina, D.: Design, Setup and Virtual Test of a Three-Section Foldable Rear Rollbar for a Low-Power Tractor. In: Ferro, V., Giordano, G., Orlando, S., Vallone, M., Cascone, G., Porto, S.M.C. (eds) AIIA 2022: Biosystems Engineering Towards the Green Deal. AIIA 2022. Lecture Notes in Civil Engineering, vol 337. Springer, Cham. (2023). https://doi.org/10.1007/978-3-031-30329-6_59
18. Ojados Gonzalez, B., Martin-Gorriz P., Sanchez, M.: Development of an automatically deployable roll over protective structure for agricultural tractors based on hydraulic power: Prototype and first tests. Computers and Electronics in Agriculture, Volume 124, June 2016, Pages 46-54 (2016). https://doi.org/10.1016/j.compag.2016.03.027
19. Gattamelata, D., Puri, D., Vita, L., Fargnoli, M.: A Full Assistance System (FAS) for the Safe Use of the Tractor's Foldable Rollover Protective Structure (FROPS). AgriEngineering. 2023; 5(1):218-235 (2023). https://doi.org/10.3390/agriengineering5010015
20. Alves, R., Matos, P.: A Solution to Prevent and Minimize the Consequences of Accidents with Farm Tractors in the Context of Mountainous Regions with Low Population Density. Sensors. 2023; 23(18):7811(2023). https://doi.org/10.3390/s23187811
21. Pessina, D., Galli, L.E., Facchinetti, D.: ROPS Design Guidelines for the Effective Driver's Protection in Case of Tractor Overturning. Safety, Health and Welfare in Agriculture and Agro-food Systems, pp.449-456 (2022). https://doi.org/10.1007/978-3-030-98092-4_46
22. Pulighe, G., Lupia, F.: Food First: COVID-19 Outbreak and Cities Lockdown a Booster for a Wider Vision on Urban Agriculture. Sustainability. 2020; 12(12):5012 (2020). https://doi.org/10.3390/su12125012
23. INAIL. L'installazione dei Dispositivi di Protezione in Caso di Ribaltamento nei Trattori Agricoli o Forestali. Linee Guida. Available online: https://www.inail.it/cs/internet/comunicazione/pubblicazioni/catalogo-generale/linstallazione-dei- dispositivi-di-protezione.html (accessed on 8 April 2021).
24. Pessina, D., Facchinetti D., Santoro F., Febo P., Orlando S., Monarca D., Cecchini M., Cutini M., Gattamelata D., Laurendi V., Pascuzzi S. (2022). Design, Manufacturing, and Strength Test of a 4-post ROPS Fitted on a Very Low-Profile Tractor (TRACLAS Project). In: Biocca, M., Cavallo, E., Cecchini, M., Failla, S., Romano, E. (eds) Safety, Health and Welfare in Agriculture and Agro-food Systems. SHWA 2020. Lecture Notes in Civil Engineering, vol 252. Springer, Cham. https://doi.org/10.1007/978-3-030-98092-4_48
25. Gattamelata D., Laurendi V., Vita L., Galli L.E., Pessina D. (2023). Design, Setup and Virtual Test of a Three-Section Foldable Rear Rollbar for a Low-Power Tractor. In Biosystems Engineering Towards the Green Deal. AIIA 2022. Lecture Notes in Civil Engineering, vol 337. Springer, Cham. https://doi.org/10.1007/978-3-031-30329-6_59