The sunrise of agricultural ergonomics and safety studies in Italy and in Europe

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Abstract
Far away to be a complete work of all the first agricultural ergonomics and safety studies in the fifties-seventies, aim of this paper is to focalize the occupational hazard problems that the researches faced at the beginning of the agricultural mechanization spread in Italy and in Europe to let a comparison with today’s situation.
European literature, standard and Italian laws of the period around 1955-1975 have been collected and examined.
Specific occupational hazards have been considered with the different approach of the researchers, with the aim to highlight safety and ergonomics operator risks in function of the mechanization level and machines spread in the different agricultural and forestry fields.
It is obvious that during the time the technology and the mechanization level have mainly displaced the axis hazards from mechanical and electrical risks to others (as physical and chemical). Among all the machines, the tractor was and is the main responsible of all the injuries type.
Unfortunately, in Italy a common risk was present at the beginning of the spread agricultural mechanization among the farms as well as nowadays: the machine overturn (66% of fatal injuries in 1957 and around 90% in 2009).

Keywords: agricultural safety, history, origins of safety studies

Introduction
It is a matter of the fact that in the safety and ergonomics studies the agriculture has always been ‘one step behind’.
The ergonomics and safety history in agriculture has been articulated itself along a difficult path, because of the different work and environment conditions, not comparable with the factories workplaces. The mechanization of the rural areas improved both the productivity and the work organization in the farms, especially in the North of the world after the Second World War, but at the meantime injuries and occupational hazards increased.
As shown in figure 1, in Italy from 1950 to 1958 an increase of power in agriculture of 336% produced there an increase of injuries of 590%. It is not difficult to understand the reasons of these increments: as Alcide de Gasperi observed at the beginning of the fifties: ‘… When I started my first trips by plane, I had the real perception of the Italian landscape. From the height I was aware of the fields slope and fragmentation (more than looking at the maps), real obstacles to a safe rural mechanization in our country.’ (Eboli, 1960).
From the legislation point of view, the concern for the protection of workers’ health and safety against occupational risks resulted in the enactment of legislation, aimed at monitoring the hazards at work and establishing the relation between the worker and his work environment. Starting from fifties, new legislation was enacted in the United States, United Kingdom, France, Italy and Sweden, to mention a few countries. Standards for controlling the various hazards were established and varying policies and programmes for educating and training workers started to be instituted at national, institutional and workplace levels.

In Italy, for example, in 1955 was launched the first organized law concerning: ‘Standards to prevent work injuries’ (D.P.R. 547/55). In this law safety indications to be applied in the workplaces were given, as well as for tools, operating machines, transport vehicles, farm plants, tanks, electric plants and dangerous materials.

Another law interesting the agricultural tractor in Italy was the D.P.R. 393/59 (Testo Unico del Codice della Strada): in the article number 29 the agricultural machines division was mentioned. In other following articles the homologation rules for tractors, agricultural trailers and self-propelled machines were described.

**Materials and methods**

European literature, standard and Italian laws of the period around 1955-1975 have been collected and examined. Specific occupational hazards have been considered with the different approach of the researchers, with the aim to highlight safety and ergonomics operator risks in function of the mechanization level and machines spread in the different agricultural and forestry fields.

**Results**

In Italy, since the second half of the fifties the researchers’ interests on agricultural safety topics increase (Gasparetto, 2002).
First studies in Italy are due to Robiony (Robiony, 1952), Carena (Carena, 1955) and Stefanelli (Stefanelli, 1956), concerning agricultural injuries analysis and tractor behaviour in sloped areas.

In 1957, a national conference concerning: ‘The adaptation of agricultural machines to the man’ occurs. The interesting thing in the title is the approach of the machine adaptation to the man, instead of the man adaptation to the machine (as the first industrialized rules advised). We are at the sunrise of ergonomics studies in agriculture.

In these years, the Italian institution which has the work to promote, to develop and to spread the injury and occupational hazard prevention is ENPI (Ente Nazionale per la Prevenzione degli Infortuni), officially founded in 1938, but reorganized in 1952.

In January, 1960, ENPI organizes the: ‘National Conference on Safety in Agricultural Mechanization’, to let researchers, public and private institutions, manufacturers, technicians and agricultural operators to meet and to discuss the emergent problems in this topic.

During the conference it is underlined that the 66% of fatal injuries are caused by tractors overturns: this problem has never been solved (in 2009 tractor overturn fatal injuries will reach the sad amount of 90%).

Another discussion argument is the electric energy utilization in agriculture: in these years the electric grid is used to operate different agricultural machines (press, threshing machine, animal feed machine, chain-saw, agricultural product transformation machineries,) using an electric engine, at fixed or not fixed point.

Another interesting discussion point is the agricultural manufacturers responsibility,’…Who are responsible to eliminate, or when it is not possible, at least to reduce the danger’ (we find these same words in the 2010 ‘Machine Directive’). In the case when a residual danger exists, the manufacturer: ‘…should provide pictures (universally understandable) near the danger point to emphasize the danger, as well as users manuals to explain machine functions and how to prevent injuries’. This is the start of pictograms and user manual spread use.

Because of the tractor overturn problem, many studies are carried out during sixties to avoid the problem, as the motor wheels misalignment, the indicator devices for transversal slope, the clutch detach, the stop of the fuel input when reaching a gradient limit. Professor Stefanelli’s studies on tractor stability concerns proposals on machine auto-stability and first protective devices against the overturn risk (Stefanelli, 1966).

At the same time a Sweden researcher observes that in worst slope and street conditions car drivers are more protected than tractor drivers because they have a ‘roof’ over the head: it is the first beginning of the protective cabs design (Gasparetto, 1968). In 1964 ASAE (American Society of Agricultural Engineers) starts to study new ROPs (Roll Over Protection systems) and cab types, to prevent injuries caused by tractors overturn (Lamouria et al., 1964).

The years of the passive safety instead of the active safety are starting, crossing from the anti-injury point of view to the ergonomics one.

At the beginning of sixties ENPI publishes the first manuals on safety in the agricultural work place, considering the double rule of the farmers: agricultural operators and mechanics, for the machines maintenance (Androni et al., 1960). In these booklets a deep discussion is dedicated to the cardan joint protection (figure 2).

At the end of the sixties, the first organized ergonomics studied starts.

Several authors have defined ergonomics as both a multi-disciplinary and interdisciplinary field of study concerned with the application of science, research and technology to improve the working and living conditions of workers. Thus, ergonomics as a field aims to prevent work injuries and illnesses so as to increase efficiency and productivity at the
workplace. The application of knowledge in ergonomics involves understanding the relation of man-machine and environment. Training in ergonomics provides one with knowledge for proper planning of workplace systems at the design stage and also furnishes a criterion for selecting the right worker for the job or the possibility of fitting the job to the worker. However, the application of ergonomics principles varies with the country and with the work site, depending both on the levels of industrialisation and mechanisation, and field application. Within developed countries in Europe, the United States and Eastern countries, ergonomics has evolved from other fields such as physiology, psychology, anatomy and engineering. Consequently, most authors or specialists in ergonomics are trained in many fields.

Figure 2: The first system of cardan joint protection (Androni et al., 1960)

In the sixties-seventies, one of the most considerable Institutions for the ergonomics studies is the NIAE (National Institute of Agricultural Engineering, Silsoe, Great Britain) which deeply studies specific topics, such as agricultural machines cabs, suspended cabs projects, tractor vibration and corresponding human answer, workplace environment, ergonomics principles in agricultural mechanization. In 1971 Matthews e Knight publish the manual: ‘Ergonomics in agricultural equipment design’. It is divided in 2 sectors (‘Ergonomics principles of design’ and ‘Application of ergonomics design principles to specific equipment’) and describes both ergonomics definitions and their applications to the agricultural machines (how to design an ergonomics agricultural machine, workplace position and layout, control design, instrumentation and display, workload, noise, vibration, climate, light and comfort, dust, repetitive works).

Anthropometric studies are in the meantime carried out, based on ISO (International Standard Organisation) data to optimize the driver workplace (figure 3).

Also agricultural manufactures are involved in the ergonomics debate in these years: in 1975 FIAT (Fabbrica Italiana Automobili Torino) publishes a paper on: ‘Human physiology applied to agricultural tractor’ (Wyss, 1975), treating the machine access, driver stress studies (cardiac cost and oxygen consumption) and whole body vibration. In the same years, John Deere publishes the first computer aid simulation studies to realize new ROPs (Smith, 1977).

Concerning this sector, various are the contributes for better ROPs studies (with also figures on projects and field tests, as NIAE does in 1970s). The interest of NIAE concerning ROPs is due to the fact that in Great Britain, starting from 1970, September, manufacturers
are obliged to mount protective chassis on tractors. Whitaker in 1975 adds a new interesting component, without which ROPs are useless: the seat belts (Whitaker, 1975).

Also in Italy we find studies concerning the tractor overturn studies and the ROPs promotion (Buldini, 1975; Robiony, 1981). In this field, UMA (Utenti Motori Agricoli) starts to awaken public opinion at National and European level to find a common strategy for safety devices mounted on agricultural machines, especially ROPs (UMA, 1975).

The machine-man interaction is deeply studied abroad (Stikeleather, 1975; Zander, 1974) as well as in Italy. Piccarolo in 1976 publishes a paper concerning ergonomics and work organization during the mechanic milking. In a different context, tractor and grape harvesting machines are considered, especially concerning rollover risks, rebounds on connection system with the tractor (due to the charge) and slip problems on the system tractor-trailer (Cappello e Cioni, 1978, Cioni, 1978).

Figure 3: Lateral views of operator’s movements while he is driving the tractor. V is the vertical plane passing through the shoulder, H is the horizontal plane of action area, SRP is the seat reference point.

Conclusions

Also if at national level almost each European country has its laws concerning safety (but not concerning agricultural machines and places), up to 1973 none European compulsory standard on agricultural and forestry machinery safety is available. Only voluntary standards, such as ISO and OECD, are in force.

In 1974 the EEC publishes the first directive concerning tractors. We must wait until 1989 (1996 in Italy) to have the first EU ‘Machine Directive’, the 98/37/CE, which has large objectives, better determined by specific standards, attaining a high level of safety, both in design and manufacturing, whilst also allowing for technical innovation.

A long time is elapsed since the first ergonomics and safety studies: nowadays we have specific standards and laws, also concerning the agricultural machines and workplaces. Injuries are diminished in the agricultural context, but certain professional diseases are increased (muscular and skeleton disorders in primis) and certain injuries continues to be fatal (tractor overturns).
Laws are necessary, but it is also necessary to think over this more than 50 years old sentence: ‘… one of the fundamental aspects … is the confirmation of some moral principles which can be summarized in the respect of the human being in his double meaning of physical and moral person …’ (Stefanelli, 1960).

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