Risk due to noise during the olive harvest: the electrical and pneumatic harvesters

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Abstract

The review of trends in farm practices and machinery development suggests that noise problems are still prevalent in agricultural situations. The aim of this study is to assess the noise exposure for workers during olive harvest in Azienda Agraria Didattico-Sperimentale of Università Politecnica delle Marche. A monitoring of noise levels is conducted in some days of the years 2010-2011.
Noise samplings were carried out on electric and pneumatic harvesters. For sound pressure levels measurements an integrating-averaging sound-level meter, B&K2250 type, was used and the measurement procedure was set up in accordance with ISO 9612:2011. The tests have been carried out during the regular working activity with all the shakers operated by the same worker expert in the use of this machines.
The results allowed to evaluate noise exposure during the olive harvest. Every machine has been analyzed to establish the level of noise produced according to the laws in force. With the collected data it was possible to establish noise exposure for every instrument. The measured sound pressure levels ($L_{p,A,eq,T}$) for all the harvesters under test are included between 70,2 db(A) and 83,5 dB(A). Noise pressure levels are higher for pneumatic type harvesters compare to electric type harvesters. The highest C-weighted peak sound pressure level ($L_{p,Cpeak}$) measured is equal to 109,8 dB(C), widely below the limits value. The daily noise exposure level determined respects the limitations in D.Lgs.81/2008 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).

Keywords: agriculture, noise exposure

Introduction

Occupational exposure to noise is one of the most significant health risk for workers being able to determine irreversible hearing damages. Noise exposure can cause different disorders and symptoms. Levels from 66 dB(A) to 85 dB(A) can involve physical and neurovegetative disorders and, sometimes, auditory damage. Levels from 86 to 115 dB(A) can cause specific effects to auditory system, such as the damage of the Corti's cells, and can involve psychosomatic diseases (Cosa, 1990). The current regulation in the European Union regarding protection of workers is based on the Directive 2003/10/CE. In Italy the safety act D. Lgs. 9 April 2008, n°81 and the following reviews are in force. This directive and the national decree state a set of minimum disposals with the aim of protecting workers from the risks for their safety and health, caused or that may be caused by the noise exposure.

The review of trends in farm practices and machinery development suggests that noise problems are still prevalent in agricultural stages, even though there has been a steady increase in the availability of materials and equipment for noise control over recent years.

In parallel to the technology development the use of machines in mechanization processes of agricultural production resulted in an increase of potential noise sources in the farm.

In recent years the use of hand-held vibrating type olive harvesters has become very common in small farms due to the high cost and time consumption of manpower in hand harvesting of olive which made mechanical harvesting convenient. However, hand-held olive harvest machines, such as pneumatic or electric harvester, can represent sources of health risk for workers in terms of noise exposure. Blandini G. has compared noise and vibrations produced by hand-held pneumatic type harvesters (Blandini G. et al., 1997). Biocca M. Has compared the noise levels of five different electrical powered machineries and one model powered by a two stroke engine; the study highlighted that noise levels of four of the five electric machines remained under the minimum limits specified in the European Directive 2003/10/CE while ear protection and/or other risk limiting procedures were required for the use of the two strokes engine model (Biocca et al., 2008). Bulent S. Has measured and evaluated the characteristics of five different electrical flap type olive harvesters pointing out that noise values at operator's ear were below risk level compared with the international standard recommendations (Bulent S. et al., 2010).

The aim of this study is to assess the noise exposure for workers during the olive harvest with hand-held type olive harvesters in Azienda Agraria Didattico-Sperimentale of Università Politecnica delle Marche. The Azienda Agraria performs the olive harvest between October and December using an electrical handheld vibrating machine. With the aim of compare noise levels of electric and pneumatic olive harvesters eight different commercial models were tested. The models tested represent a sample of machines used in small farms for the olive harvest. With the collected data it was possible to evaluate the noise exposure for every instrument. The measured data respect the D.Lgs.81/2008 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise). Measurements were carried out by using an integrating-averaging sound level meter, B&K 2250 type, during the regular working activity with all the shakers operated by the same worker expert in the use of this machines. The measurement procedure was set up in accordance with the method of UNI EN ISO 9612:2011. Microphone have been held at a distance of 0,1 m from the entrance of the external ear canal at the side of most exposed ear.

Material and Methods

All the noise sampling were performed in the years 2010 and 2011 during olive harvesting. Different campaign of measurements were carried out in the same farm during the regular working activity. Measurements have been performed on electric and pneumatic harvesters: five electric harvesters (A1 – A5), powered by 12 V d.c. motors, and three pneumatic harvesters (B1 – B3) operated by the compressed air produced by engine-driven compressors were tested.

The electric harvesters tested have different harvesting heads and bars. Harvesters A1, A2, A5 have similar harvesting capacity; harvesters A3 and A4 have a smaller harvesting capacity. The pneumatic harvesters tested have different heads but the same bar. Harvester capacity of this machines (B1, B2, B3) are comparable. The main characteristics declared by the manufacturers of the harvesters analyzed in the study are depicted in Table 1.

Table 1 Technical characteristics of the tested harvesters declared by the manufacturers

Harvester	*Description*	*Weight (kg)*	*Bar lenght (m)*	*Working cycle (60 sec^{-1})*	*Bar material*	*Rod/Rakes Material*
B 1 Pneumatic	Low working pressure (max 6 bar) Short stroke system which reduces the rake opening in order to increase beat rate. Diapason-shaped rake teeth.	2,7	2,0	1800	Aluminium	Techno polymere
B 2 Pneumatic	Working pressure 4/5 bar (max 7 bar) The rakes move sideward, each on opposite side and crossing each other. 0,2 m long teeth with rounded shape and very flexible	2,7	2,0	1600	Aluminium	Techno polymere
B 3 Pneumatic	Max working pressure 7 bar Special rakes structure 0,2 m long teeth with rounded shape and very flexible	2,7	2,0	1600	Aluminium	Techno polymere
A 1 Electric	350 W powered unit placed on the handle of the tool. The rakes move sideward	3,2	1,2-2,0	800	Carbon fiber	Carbon fiber
A 2 Electric	12 V brushless motor positioned in the lower part of the tool. Double movement of the rakes. Double length of the teethes	3,6	1,8-2,7	1080-1150	Aluminium	Thermo plastic resin
A 3 Electric	12 V power unit positioned on the handle of the tool. Oscillating motion of the teethes	2,2	2,0	750	Thermo plastic	Thermo plastic resin
A 4 Electric	12 V power unit positioned at the top of the tool. Carbon fiber rods with anti-breaking system	1,65	1,7-3,1	N.D.	Aluminium	Carbon fiber
A 5 Electric	12 V power unit positioned at the top of the tool.	2,7	2,0-3,0	1150-1250	Aluminium	Thermo plastic resins

Measurements were carried out by using an integrating-averaging sound level meter, B&K 2250 type, meeting the requirements for class 1 compliance of IEC61672-1:2002 and IEC61672-3:2006. Before and after each series of measurements a field calibration with appropriate adjustment has been performed using a sound calibrator, B&K 4231 type, meeting the requirements of IEC 60942:2003, class 1. The integrating-averaging sound level meter and the sound calibrator had a valid periodic verification report (not exceed 2 years).

The tests have been carried out during the regular working activity with all the shakers operated by the same worker expert in the use of this machines. During the test the telescopic bars of the shakers have been setted at 2 m length.

The measurement procedure was set up in accordance with the method of UNI EN ISO 9612:2011. Microphone have been held at a distance of 0,1 m from the entrance of the external ear canal. Three measurements at least for each position in right and left worker's ear and for each olive-harvester under test were performed. It has been set a measurement time of five minutes after a preliminary analysis of the noise emitted by olive-harvesters during the harvesting task. Weather and climatic condition in measurement area have been monitored during each series of measurements. Measurements with wind speed up to 4 ms^{-1} have been avoided. Airflow-induced noise has been minimized by using a windscreen of 60 mm diameter on the microphone in accordance with Technical Standards. Errors due to mechanical impacts on the sound level meter have been avoided by ensuring that both microphone and windscreen have not been touched or hit by anything.

A-weighted and C-weighted equivalent continuous sound pressure level ($L_{p,A,eq,T}$, $L_{p,C,eq,T}$), C-weighted peak sound pressure level ($L_{p,Cpeak}$) and one-third octave bands sound pressure level RMS spectrum has been simultaneously recorded for each measurement.

The A-weighted daily noise exposure level, $L_{EX,8h}$ (1) for workers involved in olive harvesting was defined using the information provided by an appropriate work analysis, selecting a task-based measurement strategy .

$$L_{EX,8h} = 10\lg\left(\sum_{m=1}^{M}\frac{\overline{T_m}}{T_o}10^{0,1\times L_{p,A,eqT,m}}\right)dBA \qquad (1)$$

Where: $L_{p,a,eqT,m}$ is the A-weighed equivalent continuous sound pressure level from task m, $\overline{T_m}$ is the arithmetic average duration of task m, T_0 is the reference duration (T_0 = 8h) and M is the total number of tasks m contributing to the daily noise exposure level.

Results

A-weighted equivalent continuous sound pressure level ($L_{p,A,eq,T}$), C-weighted equivalent continuous sound pressure level ($L_{p,C,eq,T}$) and C-weighted peak sound pressure level ($L_{p,Cpeak}$) measured at the side of most exposed ear for the eight olive harvesters under test are given in Figure 1 respectively along with the standard deviation values.

The measured sound pressure levels at each one third octave band center frequencies for all harvesters are depicted in average in Figure 2.

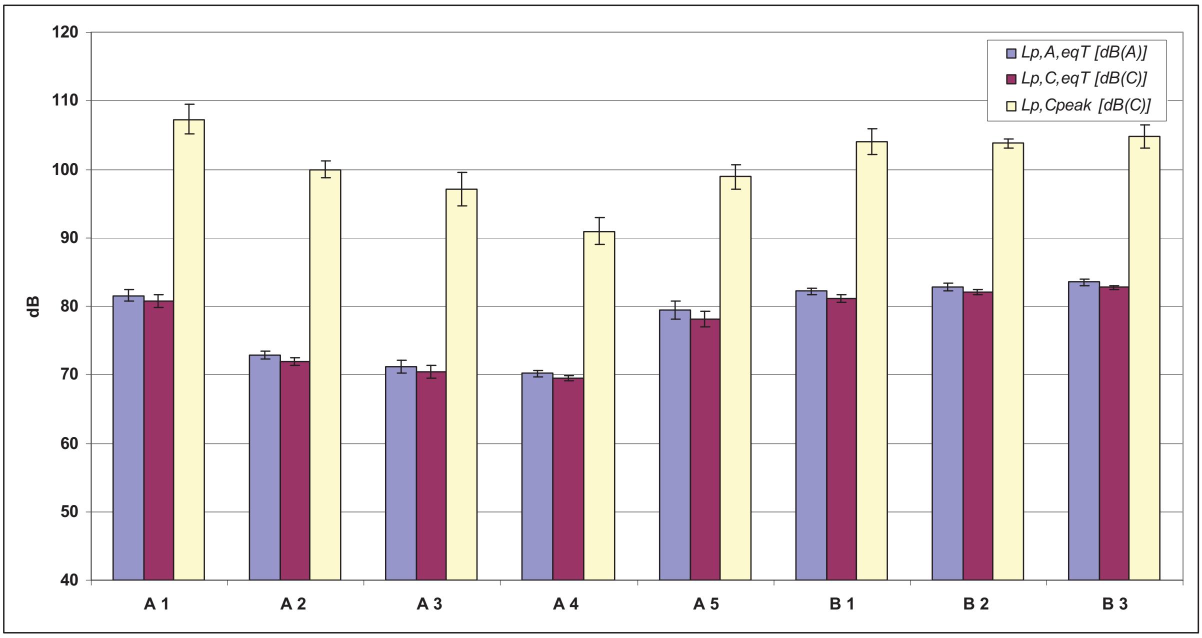

Figure 1 Sound pressure level ($L_{p,A,eq,T}$, $L_{p,C,eq,T}$, $L_{p,Cpeak}$) of olive harvesters under test

The measured A-weighted equivalent continuous sound pressure levels ($L_{p,A,eq,T}$) for all the harvesters under test are included between 70,2 db(A) and 83,5 dB(A). Noise pressure levels are higher for pneumatic type harvesters (B1 - B3) compare to electric type harvesters (A1 – A5).

Noise levels measured for the three pneumatic shakers under test were very similar, ranging from 82,2 dB(A) for B1 and 83,5 dB(A) for B3. Sound pressure levels measured for the electrical shakers were very different. Harvesters A3 and A4 showed the lowest emission levels but are also characterized by lower harvesting capacity than the others. Harvesters A1, A2, A5 comparable with regard to the harvesting capacity with pneumatic harvesters showed emission levels between 72,9 dB(A) (Harvester A2) and 81,5 dB(A) (Harvester A1). Harvester A2, which showed the lower sound pressure level, is equipped with a power unit with an automatic sensor. The sensor slows the rakes down when they are out of the branches and restores their harvesting speed when they touch the foliage. This solution seem to be useful to limit noise emissions during the harvesting task.

The highest C-weighted peak sound pressure level ($L_{p,Cpeak}$) measured is equal to 109,8 dB (C) (Harvester A1), widely below the limits value.

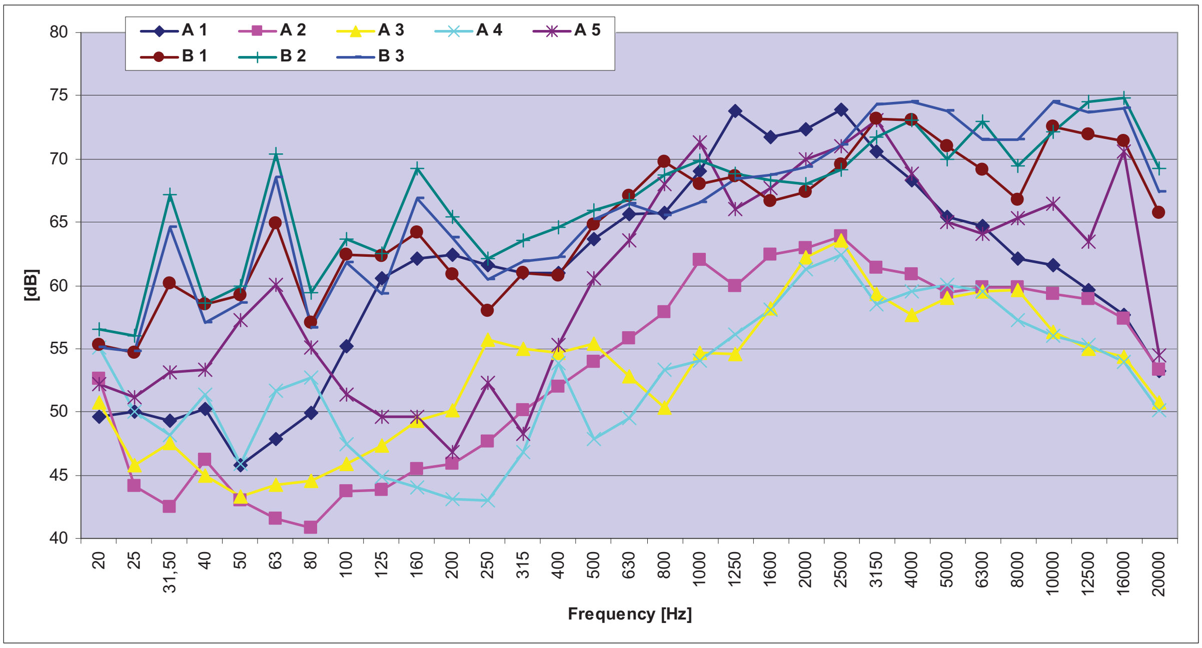

Figure 2 One-third octave bands sound pressure level RMS spectrum measured

The frequency spectrum curves of the noise showed similar trends for the three pneumatic harvesters (B1 – B3). The spectra showed some tonal components at low frequency the first of which at 31 Hz. This tonal component correspond to the beat rate of the rakes of 1600-1800 movements per minute. The frequency spectrum curves also showed appreciable sound pressure level for all the frequencies but especially on medium-high frequencies (2000-16000 Hz). Human auditory system is most sensitive between 2000 Hz and 5000 Hz (ISO 226:2003) where pneumatic harvesters under test showed higher sound pressure level than the electric harvesters.

The five electric harvesters under test (A1 – A5) showed different sound pressure level spectrums but with lower sound pressure levels than the pneumatic shakers especially at low and high frequencies. Harvester A5 showed higher emission levels between 1000 Hz and 2000 Hz than sound pressure levels measured for the pneumatic shakers under test.

The daily noise exposure level, $L_{EX,8h}$ for workers involved in olive harvesting in Azienda Agraria Didattico-Sperimentale of Università Politecnica delle Marche was determined for the Harvester A1, the electric harvester owned by the Farm. The work analysis provided information to defined the workers nominal day. The nominal day of each worker consist of sequence of four different tasks: harvesting task with handheld olive harvester (3 h), displacement of the collection nets (3 h), collecting of the olive from the networks (1,5 h) and work planning/break (0,5 h). All workers perform the same work and therefore can be regarded as one homogenous noise exposure group.

Noise contribution from the olive collecting from the net and from work planning/break is negligible to the noise exposure level. These tasks are accomplished in the absence of noise sources. The noise measurements done in this working period showed an A-weighted equivalent continuous sound pressure level ($L_{p,A,eqT}$) minor than 60 dB(A). The noise level during the displacement of the collection nets was determined with three measurement of 5 min. This task is performed in the area affected by the noise generated by the harvester in use. Tasks, time spend for each task and measurement results are shown in Table 2.

Table 2 Worker's nominal day and noise levels measured

Task	Duration h	Noise level $L_{p,A,eqT}$ dB(A)		
		Meas. 1	Meas. 2	Meas. 3
harvesting task	3	80,6	82,2	81,8
displacement of the net	3	72,1	74,2	71,6
collecting of the olive from the net, breaks	2	60	60	60

The expanded uncertainty was determined in accordance with ISO 9612. The standard uncertainty due to sampling noise levels is calculated; the standard uncertainty due to instrumentation was fixed to 0,7 dB, the standard uncertainty due to the microphone position was fixed to 1 dB; the uncertainty in duration was excluded.

During the olive harvest, the workers are subjected to a daily A-weighted noise exposure level (1) of 77,9 dB with an associated expanded uncertainty for a one side coverage of 95% (K=1,65) of 2,1 dB.

Conclusion

The present study has focused on the evaluation of noise exposure for workers during the olive harvest in Azienda Agraria Didattico-Sperimentale of Università Politecnica delle Marche. Eight different commercial models were tested with the aim of compare the noise levels of electric and pneumatic olive harvesters Eight different commercial models were tested. The results showed that A-weighted sound pressure levels ($L_{p,A,eq,T}$) measured for all the harvesters under test are included between 69 db(A) and 83,5 dB(A). The highest C-weighted peak sound pressure level ($L_{p,Cpeak}$) measured is equal to 109,8 dB (C), widely below the limits value.

Noise pressure level are higher for pneumatic type harvesters compare to electric type harvesters. Noise levels measured for the three pneumatic shakers under test ranged from 82,2 dB(A) and 83,5 dB(A). Pneumatic machines showed similar trends of the frequency spectrum curves with some tonal components at low frequency, corresponding to the beat rate of the rakes, with appreciable sound pressure level for all the frequencies but especially on medium-high frequencies (2000-16000 Hz). Noise levels measured for the electrical shakers were very different, ranging from 70,2 dB(A) and 81,5 dB(A) but with four of the five machines were under 80 dB(A). One of the electrical machines is equipped with a power unit with an automatic sensor which slows the rakes down when they are out of the branches and restores their harvesting speed when they touch the foliage. This solution seem to be useful to limit noise emissions during the harvesting task.

The daily noise exposure level, $L_{EX,8h}$ for workers involved in olive harvesting in Azienda Agraria Didattico-Sperimentale of Università Politecnica delle Marche, determined for the electric harvester owned by the Farm, showed respect to the limitations in D.Lgs.81/2008 on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (noise).

In the future new measurement sessions will be conducted with the aim of further validate the data collected and identify the influence of each of the technical characteristic of the harvesters on the sound pressure levels emitted. The aim of the research will be to study the reduction of the noise levels on an olive harvester type and define possible interventions with low technical and economic impacts to be made to the harvester model examined for the reduction of the noise.

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