Noise Levels for Modern Hazelnut Harvesters

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Abstract

A research has been carried out to assess the noise exposure for workers during mechanized harvesting of hazelnuts. The survey has been performed in the years 2006 and 2007 in four farms in Piemonte (Italy) in the province of Cuneo, in the typical area of the cultivar "Tonda Gentile of Langhe".

The noise samplings were carried out on hazelnut harvesters and during the use of blowers or swathers: three tractor mounted picking harvesters; four self-propelled harvesters (three vacuum harvesters and one picking harvester); one towed vacuum harvester; one swather; two blowers. For the sound pressure measurement a personal dosimeter Larson-Davis 705 was used. The noise levels obtained from this study have been compared with the law currently in force in Italy.

The data elaboration allowed to determine the values of the daily noise exposure level ($L_{EX,8h}$) for workers. All the results show the exceeding of the exposure limit value fixed by legislative decree 81/2008 in 87.0 dB(A). The highest peak value, equal to 126,6 dB(C), is below the limit values fixed by the above-mentioned law.

Keywords: noise exposure, hazelnut harvesting, work hygiene

Introduction

Noise is one of the main risk factors for agricultural workers during hazelnuts' harvesting; it is due to the use of machines. The problem of noise exposure is still not completely resolved, although the introduction of cabin could reduced exposure to levels below the lower action value provided by legislative decree 81/08.

The choice of the machine must be done carefully, considering not only the work performance (operational capabilities, "quality" of work, etc.), but also and above all safety and hygiene aspects (Monarca *et al.*, 2005). Who buys a machine should therefore pay attention to the values of sound pressure (and power) level declared by the manufacturer, preferring the models with less production of harmful physical agents.

Materials and methods

The survey has been performed in the years 2006 and 2007 in four farms in Piemonte (Italy) in the province of Cuneo in the typical area of the cultivar "Tonda Gentile of Langhe":

- Cravanzana: altitude 585 m above sea level (min 369; max 716) – latitude 44° 34'32"52N;
- Torre Bormida: altitude 391 m a.s.l. (min 269; max 680) – latitude 44° 33'49"32N;
- Bosia: altitude 484 m a.s.l. (min 340; max 700) – latitude 44° 36'12"24N;
- Feisoglio: altitude 706 m a.s.l. (min 475; max 823) – latitude 44° 32'40"92N.

The surveyed farms have different characteristics in term of the type of corporate form, of extension, of used machines, of availability of labor and harvesting procedures.

Before the campaign survey 2006 for each company was made a statement on the company structure (total areas and nut area, number of plots, etc.), the characteristics of the orchard (plant distances and age), cultural practices and used equipment and machinery (data not reported).

During the two years two campaign of measurements were carried out: the first one during the main harvesting (last decade of August); the second one during the first decade of September. The harvesters used during the campaign of measurements are reported in table 1.

Table 1. Tested machines

Machine	Manufacturer	Model
Tractor mounted picking harvester (connected with mechanical transmission to the tractor Carraro TRX7400)	G.F.	Jolly 1800
Tractor mounted picking harvester (connected with hydraulic transmission to the tractor New Holland TN 75 FA)	G.F.	Jolly 1800
Tractor mounted picking harvester (connected with mechanical transmission to the tractor Carraro TRX7400)	Rivmec	Smart 1800
Towed vacuum harvester	Facma	Cimina 300T
Self-propelled vacuum harvester	Facma	Cimina 300S
Self-propelled vacuum harvester	Facma	Cimina 200S
Self-propelled vacuum harvester	Facma	Cimina 380S
Self-propelled picking harvester	Agrintem	Perla 55
Swather	BCS	-
Blower	Shindaiwa	EB 8510
Blower	Echo	PB 6000

a) b) c)

Figure 1. Some of tested machines: a) Facma 380S, b) Rivmec Smart 1800, c) GF Jolly 1800 (courtesy of manufacturing companies).

The reference laws for the assessment of workers noise exposure is the Title VIII (Physical agents), Chapter II (Protection of workers against the risks of exposure to noise at work) of the legislative decree 81/08. Table 2 shows the reference levels established by law.

The daily ($L_{EX,8h}$) and weekly ($L_{EX,w}$) noise exposure level are defined by law as follows:

- daily noise exposure level ($L_{EX,8h}$) (dB(A) ref. 20 μPa): time-weighted average of the noise exposure levels for a nominal eight-hour working day as defined by international standard ISO 1999: 1990, point 3.6. It covers all noises present at work, including impulsive noise;
- weekly noise exposure level ($L_{EX,w}$): time-weighted average of the daily noise exposure levels for a nominal week of five eight-hour working days as

defined by international standard ISO 1999:1990, point 3.6

The peak sound pressure (p_{peak}) is defined as the maximum value of the 'C'-frequency weighted instantaneous noise pressure.

Table 2. Legislative limits

Limit value	$L_{EX,8h}$ or $L_{EX,w}$ (dBA)	p_{peak} (Pa)	p_{peak} (dBC)
Exposure limit value	87.0	200	140.0
Upper action value	85.0	140	137.0
Lower action value	80.0	112	135.0

The measurements was carried out with a class 1 data-logging personal sound level meter model "Noise Badge 705" produced by Larson Davis (3425 Walden Avenue Depew, New York 14043 USA) (figures 2 and 3). The personal sound level meter can measure the noise dose to which a person is exposed in a given period of time. Dose means the sound level limit ('*A*' weighted) at which a worker may be exposed during an eight hours working day, without the risk of hearing loss. The device is small with limited thickness and weight, so it can be comfortably worn by the operator. The supplied microphone is wire connected to the instrument and is placed on a metal rod fixed to a helmet so that the distance between the microphone and the ear is about 10 cm.

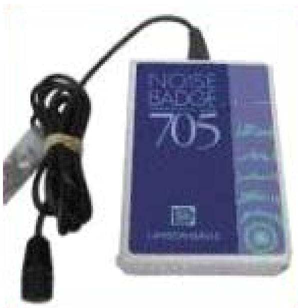

Figure 2. Personal Sound Level Meter "Noise Badge 705" (courtesy of Larson Davis)

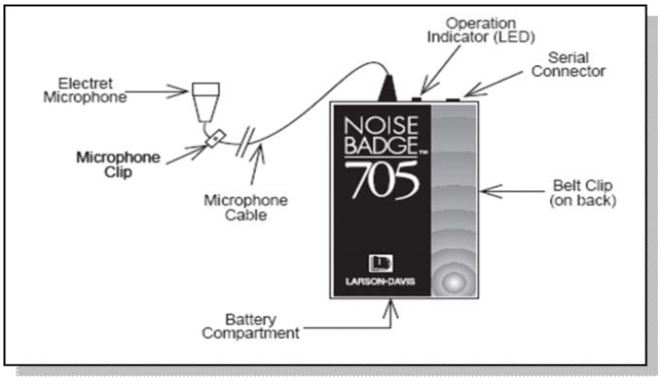

Figure 3. Components of personal Sound Level Meter "Noise Badge 705" (courtesy of Larson Davis)

Apparatus, before being used for data acquisition, should be initiated through the software provided by the manufacturer. A calibration of the instrument should be done before any measurement campaign. For this purpose a class 1 sound calibrator model CAL 200 produced by Larson Davis was used.

Through the supplied cable, the instrument was connected to the computer's serial port for its programming. Once the data were acquired it was necessary reconnecting the sound level meter to the computer for their downloading.

The software automatically process the collected data allowing to provide the L_{Aeq}

values used to calculate the daily noise exposure levels ($L_{EX,8h}$). Figures 4 and 5 show some screens provided by the software.

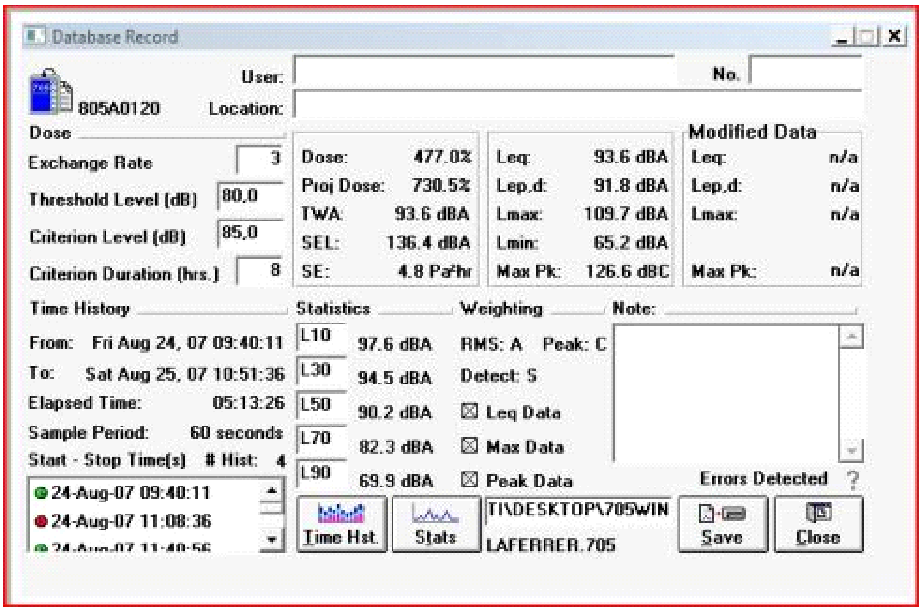

Figure 4. Sample screen for processing the file (software Larson Davis)

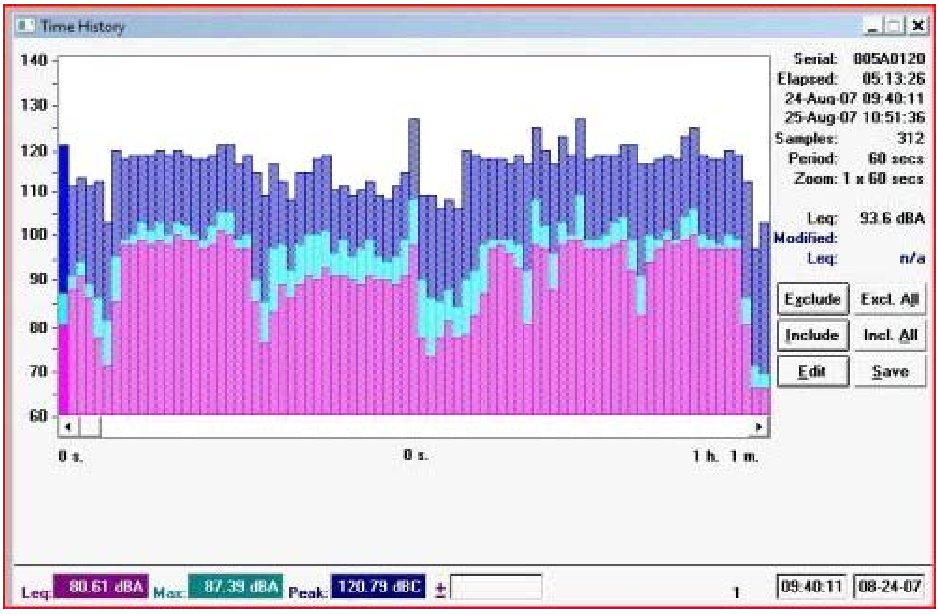

Figure 5. Example of graph processed by the software Larson Davis

Once carried out the measurements the daily noise exposure levels ($L_{EX,8h}$) for workers involved in hazelnut harvesting were calculated, using the formula:

$$L_{EX,8h} = L_{Aeq,Te} + 10\log(Te/To) \qquad \text{dB(A)} \qquad (1)$$

Results

The data processing performed using the Larson Davis software allows to extrapolate the values of L_{Aeq} levels for each test. The data, processed with a spreadsheet, have determined the average daily noise exposure values $L_{EX,\ 8h}$, which show the exceeding of the daily exposure limit value set by decree 81/2008 in 87 dB(A). The highest peak value equal to 126.6 dB(C) is instead widely below the limits values.

Table 3: Sound pressure levels (L_{Aeq}) and daily noise exposure level ($L_{EX,8h}$)

Machines	L_{Aeq} (dBA)	$L_{EX,8h}$* (dBA)
Tractor mounted picking harvester G.F. Jolly 1800 connected with mechanical transmission to the tractor Carraro TRX7400	90.8 ÷ 91.4	91.1
Tractor mounted picking harvester G.F. Jolly 1800 connected with hydraulic transmission to the tractor New Holland TN 75 FA	86.9	86.9
Tractor mounted picking harvester Rivmec Smart 1800 connected with mechanical transmission to the tractor Carraro TRX7400	94.1	94.1
Towed vacuum harvester Facma Cimina 300T	90.7 ÷ 94.3	92.9
Self-propelled vacuum harvester Facma Cimina 380S	92.6	92.6
Self-propelled vacuum harvester Facma Cimina 300S	89.1 ÷ 95.0	93.0
Self-propelled vacuum harvester Facma Cimina 200S	91.4	91.4
Self-propelled picking harvester Agrintem Perla 55	91.3 ÷ 94.8	93.4
Swather BCS	95.1	93.9
Blower Shindaiwa EB 8510	95.8	94.6
Blower Echo PB 6000	93.8	92.6

**harvesters: Te = 8h; swather and blowers: Te = 6 h.*

The greatest daily exposure level in harvesting operations was obtained with the use of tractor mounted Smart 1800, and the lowest exposure level (except the test on a tractor with cab) with the tractor mounted GF Jolly 1800. The two harvesters (Jolly 1800 and Smart 1800) are very similar. So we can underline that tractor is very important in determining the noise levels eared by workers.

Another important observation emerging from data collected is that, at current technology status, the only solution to reduce noise exposure levels below the limit value is to use machines with cab (e.g.: tractor New Holland TN 75 FA). The influence of the kind of used transmission (hydraulic or mechanical) could have a great influence on sound pressure levels, but available data do not allow evaluating their incidence on noise production.

The harvesting is not the only dangerous operation (from the point of view of noise exposure): also the previous operations of raking (with the use of swathers or blowers) show noise exposure levels exceeding the limit of 87 dB(A).

Conclusions

The use of personal sound level meter Larson Davis Noise Badge 705, given to workers involved in hazelnut harvesting, allowed to assess their noise exposure levels.

The daily noise exposure levels during hazelnut harvesting, calculated without taking into account the use of individual protection devices, ranged from 86.9 to 94.4 dB(A), with peak values ranging from 122.8 dB(C) and 126.6 dB(C).

In all the samples (except the test on a tractor with cab) was exceeded the exposure limit value set at 87 dB(A) by the legislative decree 81/08, but not for the sound pressure peak, which was always under the lower action value.

Analyzing sound pressure levels by type of machine, self-propelled show an average of 92.7 dB(A), towed harvesters an average of 94.4 dB(A) and tractor mounted harvesters an average of 95.5 dB(A). For the latter the contribution due to noise from the tractor used is very important, and is perhaps more correct to analyze the matching machine-tractor. The use of cab tractors can significantly reduce the noise exposure of workers.

Noise exposure levels exceed the limit of 87 dB(A) also during the use of blowers and swathers for raking operations.

It should be emphasized that noise exposure, resulting from the use of machinery for tillage and hazelnuts harvesting, is limited to 15-20 days/year for larger companies and to few days for smaller ones (Monarca and Zoppello, 1993).

These exposure levels require employers to take immediate preventive measures to bring exposure levels below the exposure limit value. Reducing the exposure time does not seem to be a feasible measure, given the limited duration of the harvesting period. So workers must wear apposite individual protection devices (ear muffs, inserts), and they must be informed and trained as provided by the directive 2003/10/CE on the protection of workers from exposure to noise.

The manufacturer, given that the examined machines are characterized by sound pressure levels greater than 85 dB(A), must report on the "utilization and maintenance" manual, as required in the "machinery directive", the value of sound power of the machine.

Furthermore, the manufacturer should hypothesize and implement various interventions that may reduce the value of sound emissions of the machine. Thus, deep surveys to individuate all sources of sound emission on the machine are needed and an enhancement program must be implemented.

It is possible to work on noise sources and on noise propagation. As it regards these last interventions, it is important to be aware that the noise emitted by any source can be directly spread by air or by solid (for instance, through the machine frame).

Interventions on sources are always to be favoured because they remove the noise (risk) directly at the source (Monarca *et al.*, 2009). It is necessary to look for the application of noiseless functioning systems on the machine and try to decrease the high noise of some sources.

In order to do so a deepen study on all the components of the machine is needed (for instance through the measure of sound intensity), thus the possible intervention points can be highlighted. If the noise of the sources is caused by lacks in the designing phase, these must be immediately removed or corrected. Then, the noise origin must be determined:

- if the noise has a mechanic origin (rotating elements, transmission elements like gears and bushes, metallic collisions), speed and load must be reduced, so as the vibrations transmitted to the surfaces must be eliminated;
- if the noise has an aerodynamic origin, beside the utilization of sound dampers, it is necessary to correct the loops and the fan functioning; rotation noises and fluid vorticity must be reduced.

Interventions on propagation can be realized through different strategies:

- damping pads: are necessary in case of vibrations transmitted to the frame from the engine or the fans used for air suction. The same kind of intervention can be used to eliminate the continuity of extended metal structures.

- Integral shrouding: is an intervention to be done when it is no longer technically possible to reduce the noise of the source. It is required when a big noise reduction is needed (at least 15-20 dB). It is a very effective kind of intervention, but the costs are often high and it is not always technically feasible.
- Partial shrouding: it can be useful when it is not possible to close all the machine, when the decrease needed is not greater than 15 dB, when the frequencies to be lowered are medium-high. Interventions of partial shrouding can determine reduction of sound power for the operator ear between 3-5 dB and 12-15 dB.
- Worker isolation: in same cases it can be useful to isolate in a sound-insulating cabin the operator (such intervention can be also useful against other risks, like dust). It is a feasible and advisable kind of intervention for many noisy machines for which a reduction of noise at the source or integral shrouding are not reasonably practicable. For the self propelled nut harvester the driving cab is not easily realizable because the machine must operate in orchards, but first models of self propelled harvesters with cab are nowadays on the market (figure 6).

Figure 6. A nut harvester with cab (courtesy of Asquini)

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The contribution to the programming and executing of this research must be equally divided by the authors.