Ciência Rural, Santa Maria, v.53:6, e20210695, 2023
http://doi.org/10.1590/0103-8478cr20210695
ISSNe 1678-4596
RURAL ENGINEERING

# Occupational noise level emitted by self-propelled harvesters during mechanized coffee harvesting

**Kleber Moreira Martins[1*] Paulo Henrique de Siqueira Sabino[2] Adriano Bortolotti da Silva[2] Geraldo Gomes de Oliveira Júnior[3] Lucas Deleon Ramirio[3]**

[1]Departamento de Segurança do Trabalho, Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais (IFSULDEMINAS), Campus Muzambinho, 37890-000, Muzambinho, MG, Brasil. E-mail: kleber.seapa@gmail.com. *Corresponding author
[2]Programa de Pós-graduação em Agricultura Sustentável, Universidade José do Rosário Vellano (UNIFENAS), Alfenas, MG, Brasil.
[3]Departamento de Segurança do Trabalho, Instituto Federal de Educação, Ciência e Tecnologia do Sul de Minas Gerais (IFSULDEMINAS), Muzambinho, MG, Brasil.

**ABSTRACT**: This study evaluated the level of occupational noise emitted by automotive harvesters during coffee harvest. For the evaluations, three self-propelled harvesters were used: Case-IH® model Coffee Express 200, with cabin; Korvan® model 9200, without cabin; and Oxbo® model 9220, with cabin. Data were collected using a noise dosimeter model DOS-700. Noise levels were assessed for the operator and assistant of each harvester. Five repetitions were performed for the operator and assistant, with each repetition consisting of 2 h of evaluation. Results obtained were compared with the action level and exposure limit of the Regulatory Norms (NR) 15 and Occupational Hygiene Norms (NHO) 01. The action levels of the NHO 01 (82 dB) and NR 15 (80 dB) regulations were exceeded for the operator and assistant in the three evaluated harvesters. Regarding the exposure limit (85 dB), the level was exceeded for the operator of the Korvan® and Case-IH® harvesters in accordance with NHO 01. In the NR 15 regulation, the exposure limit was > 85 dB for the operator of the Korvan® harvester. For the assistant, all harvesters emitted noise levels > 85 dB based on both the NHO 01 and NR 15 regulations.
**Key words**: coffee, mechanization, NR 15; NHO 01, rural workers.

## Nível de ruído ocupacional emitido por colhedoras automotrizes na colheita do cafeeiro

**RESUMO**: O uso da mecanização na cafeicultura tem se mostrado de suma importância na colheita do cafeeiro, reduzindo custo e tempo desta operação. Entretanto, a intensificação da colheita mecanizada, sem o controle dos riscos ocupacionais tem exposto trabalhadores aos níveis elevados de ruído ocupacional capazes de comprometer sua saúde auditiva. O objetivo do trabalho foi avaliar o nível de ruído ocupacional emitido por colhedoras automotrizes na colheita do cafeeiro, bem como os limites de exposição e nível de ação do operador e auxiliar. Para as avaliações foram utilizadas três colhedoras automotrizes: Case-IH® modelo COFFE EXPESS 200, com cabine; OXBO® modelo 9220, com cabine; KORVAN® modelo 9200, sem cabine. A coleta dos dados foi realizada utilizando dosímetro de ruído modelo DOS-700. Foi avaliado o nível de exposição ao ruído do operador e auxiliar das colhedoras. Foram realizadas cinco repetições, sendo cada repetição formada por duas horas de avaliações. Os dados obtidos foram comparados com o nível de ação e limite de exposição das normativas NHO 01 e NR 15. O nível de ação das normativas NHO 01 (82 dB) e NR 15 (80 dB) foram ultrapassados no operador e auxiliar nas três colhedoras avaliadas. Em relação ao limite de exposição (85 dB), o nível foi ultrapassado no operador das colhedoras KORVAN® e Case-IH® de acordo com a NHO 01. Na normativa NR 15, o limite de exposição ficou acima de 85 dB no operador da colhedora KORVAN®. No auxiliar todas as colhedoras emitiram níveis de ruídos acima de 85 dB tanto na normativa NHO 01 quanto na NR 15.
**Palavras-chave**: café**,** mecanização, NR 15, NHO 01, trabalhadores rurais.

Coffee production has undergone changes, especially in the harvesting process, with the use of self-propelled harvesters. However, the use of self-propelled harvesters without proper care can expose workers to high occupational noise levels, which can be harmful to their health (CUNHA et al., 2016). Occupational noise can be defined as any type of sound that has the potential to

**Received 09.22.21 Approved 06.13.22 Returned by the author 08.11.22**
**CR-2021-0695.R3**
**Editors: Leandro Souza da Silva Marcelo Silveira Farias**

cause auditory and extra-auditory damage to workers (CAMISASSA, 2021).

In Brazil, Regulatory Standard NR 15 and Occupational Hygiene Standard NHO 01 establish 85 dB as the noise exposure limit for an 8-h work day (FUNDACENTRO, 2001; BRASIL, 2021). Moreover, the standards use action levels as a preventive measure against noise emissions exceeding the worker's exposure limit: NHO 01 establishes 82 dB, while NR 15 establishes 80 dB as the action level. Thus, this study assessed the levels of occupational noise emitted by self-propelled harvesters in coffee harvesting and the exposure limits and action levels for the operator and assistant.

This study was conducted in the municipality of Alfenas in the southern region of Minas Gerais, Brazil. The data were obtained from coffee trees planted in a flat relief. Noise exposure levels (ELs) were evaluated for the operator and assistant in three commercially available self-propelled harvesters, two with cabins and one without a cabin: Case-IH® model Coffee Express 200, with cabin; Oxbo® model 9220, with cabin; and Korvan® model 9200, without cabin. Harvesters with and without cabins were intentionally selected to determine the noise attenuation capacity of the operator. All harvesters operate in the following conditions: gear, third reduction; speed, 1600 $m.h^{-1}$; and rotation, 2200 rpm.

Noise levels were collected with a personal-use integrating meter, a noise dosimeter by Instrutherm, model DOS-700, which was electronically calibrated and certified by the Brazilian Calibration Network (RBC) in the field using the calibrator model CAL-4000 Instrutherm IEC 942/ CLASSE 2, with sound pressure levels between 94 and 114 dB and a continuous noise classification, before and after the measurements were made.

A device with a microphone was installed at a distance of 15 cm from the ear (NHO 01) of the operator and assistant of the self-propelled harvesters. The operator drives the self-propelled harvesters, while the assistant organizes the large bags where the harvested coffee berries are placed.

Dosimetry was performed to represent the work day, observing mealtimes. An entirely randomized 3×2 factorial design was adopted, with three self-propelled harvesters, Case-IH®, Oxbo®, and Korvan®, and two workers per harvester, the operator and assistant. Five repetitions were conducted for the operator and assistant in each harvester, and each repetition consisted of 2 h of dosimetry in an effective work, totaling 10 h of evaluations for the operator and assistant in each harvester.

After the evaluation and data collection, the EL in dB (A) was determined using equation 1 (Eq. 1), according to NHO 01:

$$EL = \log\left(\frac{480}{T_E} \text{ X } \frac{D}{100}\right) + 85\ [dB] \quad \text{(Eq. 1)}$$

where *EL* is the exposure level, *D* is the daily dose of noise in percentage; $T_E$ and is the duration of the daily work day in minutes.

To perform a comparative analysis between NHO 01 and NR 15, the EL for NR 15 was calculated using equation 2 (Eq. 2):

$$EL = 16{,}91 \log\left(\frac{480}{T_E} \text{ X } \frac{D}{100}\right) + 85\ [dB] \quad \text{(Eq. 2)}$$

where *EL* is the exposure level, *D* is the daily dose of noise in percentage, and $T_E$ is the duration of the daily work day in minutes.

To compare the exposure limit, the normalized EL was initially calculated using equation 3 (Eq. 3), according to NHO 01, and equation 4 (Eq. 4), according to NR 15:

$$NEL = EL + 10 \log \frac{T_E}{480}\ [dB] \quad \text{(Eq. 3)}$$

where *NEL* is the average level representing the daily occupational exposure and $T_E$ is the duration of the daily work day in minutes.

$$NEL = EL + 16{,}91 \log \frac{T_E}{480}\ [dB] \quad \text{(Eq. 4)}$$

where *NEL* is the average level representing the daily occupational exposure and $T_E$ is the duration of the daily work day in minutes.

The Shapiro-Wilk test was employed to analyze the noise levels for normality. The data presented normal distribution ($P > 0.05$). Next, analysis of variance was conducted, and the means were compared by the Scott-Knott test at a 5% significance level using R software version 3.2.4 (R CORE TEAM, 2016).

Interactions were observed between the harvesters and the operator and assistant for NHO 01 ($gl = 2$; $F = 6.79$; $P < 0.05$) and NR 15 ($gl = 2$; $F = 6.78$; $P < 0.05$) (Table 1). In the comparison between the operator and assistant, the Korvan® harvester was the only harvester that showed comparable results between operator and assistant. In the case of the Oxbo® and Case-IH® harvesters, the assistant was exposed to higher noise levels than the operator (Table 1). The Korvan® harvester presented the highest occupational noise level in the auditory zone of both the operator and assistant compared to the Case-IH® and Oxbo® models (Table 1).

In all conditions assessed in the study, the action levels of 82 dB for NHO 01 and 80 dB for NR 15 were exceeded, confirming the need to adopt preventive measures to minimize the probability of exposure exceeding the established limits. Preventive actions should include monitoring exposure, providing orientation and instruction

Table 1 - Operator's and assistant's level of exposure to occupational noise (dB) (± standard error) emitted by different self-propelled harvesters during coffee harvesting, assessed according to NHO 01 and NR 15.

| ----------NHO 01---------- | | |
|---|---|---|
| Harvester | Operator | Assistant |
| Oxbo® | 84.36* ± 1.09 b B | 89.08 ± 0.55 b A |
| Case-IH® | 85.54 ± 0.57 b B | 90.36 ± 0.69 b A |
| Korvan® | 92.32 ± 0.10 a A | 92.94 ± 0.17 a A |
| ----------NR 15---------- | | |
| Harvester | Operator | Assistant |
| Oxbo® | 82.16* ± 1.34 b B | 88.32 ± 0.63 b A |
| Case-IH® | 83.64 ± 0.52 b B | 88.98 ± 1.04 b A |
| Korvan® | 92.32 ± 0.10 a A | 92.94 ± 0.17 a A |

*The means followed by the same lowercase letters in the column and the same uppercase letters in the row do not differ from each other based on the Scott-Knott test at 5% significance level.

to workers, and medical supervision through audiometry exams.

The results showed that the operator was exposed to noise emissions under the exposure limit of 85 dB only in the Oxbo® harvester, according to NHO 01 (Table 1). Based on NR 15, the operator was exposed to noise levels under the exposure limit in the Oxbo® and Case-IH® harvesters (Table 1).

Generally, the cabins in the Oxbo® and Case-IH® self-propelled harvesters attenuated the noise level for the operator, as proposed by some manufacturers who offer driver cabins for agricultural machinery so as to maintain noise levels < 85 dB (CELEN & ARIN, 2003), a strategy for reducing exposure to occupational noise.

In other interactions between the harvesters and the operator and assistant for the NHO 01 and NR 15 standards (Table 1), noise emissions by the self-propelled harvesters exceeded the exposure limit (85 dB) for both the operator and assistant for a complete 8-h work day. Therefore, operators and assistants involved in mechanized coffee harvesting cannot perform their activities without the use of personal protective equipment, namely, hearing protectors.

These results are similar to those reported by Silva et al. (2018), who examined noise levels in mechanized activities in the coffee harvesting process and found values above the exposure limits allowed by NR 15 and NHO 01. According to the same authors, the highest noise levels were found in the use of the tractor and blower set at 100.7 dB.

The results of this study showed that mechanized harvesting of coffee trees with self-propelled harvesters exceeded the action level for the operator and the assistant, according to NHO 01 and NR 15. Consequently, mitigation measures are needed to reduce the potential damage caused to workers' health, including reducing the operator's and assistant's working hours or providing hearing protection that can attenuate occupational noise.

Under the conditions in which the work was performed, the self-propelled harvesters emitted noise above the action level set forth in NHO 01 and NR 15 for both the operator and assistant. The exposure limit for the operator was exceeded in the Korvan® harvester based on the NHO 01 and NR 15 standards, while the exposure limit for the assistant was exceeded in the three harvesters based on both standards. The cabins of the self-propelled harvesters Oxbo®, based on NHO 01 and NR 15, and Case-IH®, based on NR 15, are effective in reducing occupational noise for the operator.

## ACKNOWLEDGEMENTS

The present work was carried out with the support of the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES).

## DECLARATION OF CONFLICT OF INTEREST

The authors have no conflicts of interest to declare. The financial sponsors had no role in the research design; data collection, analysis, or interpretation; writing the manuscript; or decision to publish the results.

## AUTHORS' CONTRIBUTIONS

All authors contributed equally to the conception and writing of the manuscript.

## REFERENCES

Ministry of Labour and Employment. **National School of Labour Inspection - ENIT**. Norma Regulamentadora (Regulatory Standard). NR 15 "Atividades e operações insalubres". ENIT, 2021.

CAMISASSA, M. Q. **Segurança e Saúde no Trabalho. NRs 1 a 37: comentadas e descomplicadas**. 7.ed. Rio de Janeiro: Editora Método, 2021. 843p.

CUNHA J. P. B. et al. Field efficiency in different mechanized operations in coffee farming. **Coffee Science**, v.11, n.1, p.76-86, jan./mar. 2016. Available from: <http://www.sbicafe.ufv.br/bitstream/handle/123456789/8175/Coffee%20Science_v11_n1_p76-86_2016.pdf?sequence=1&isAllowed=y>. Accessed: Dec. 7, 2019.

CELEN, I. H.; ARIN, S. Noise Levels of Agricultural Tractors. **Pakistan Journal Of Biological Sciences**, v.6, n.19, p.1706-1711, Dec. 2003. Available from: <https://docsdrive.com/pdfs/ansinet/pjbs/2003/1706-1711.pdf>. Accessed: Nov. 15, 2019. doi: 10.3923/pjbs.2003.1706.1711.

FUNDAÇÃO JORGE DUPRAT FIGUEIREDO - FUNDACENTRO. **Norma de higiene ocupacional NHO 01**: avaliação da exposição ocupacional ao ruído. São Paulo, 2001. 41p.

R DEVELOPMENT CORE TEAM. **R**: Foundation for Statistical Computing, Vienna, Austria, 2016.

SILVA, J. A. R. et al. Occupational noise level in mechanized and semimecanized haverst of coffee fruits. **Coffee Science**, Lavras, v.13, n.4, p.448-454, oct./dec. 2018. Available from: <http://www.coffeescience.ufla.br/index.php/Coffeescience/article/view/1468>. Accessed: Dec. 9, 2019.