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REGULAR ARTICLE

Can the tractor's cabin allow the noise at the operator's station?

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Abstract

Constant exposure to high noise levels can cause health problems for agricultural machinery operators. Machines equipped with closed cabs can attenuate noise and preserve the operator from an unhealthy condition. Some studies show that in cabin tractors it is possible to renounce the use of hearing protection, however indoor equipment and air conditioning can reach high levels of noise, which need to be further investigated. The present study aimed to evaluate the noise emitted by a cabined agricultural tractor, in different points, inside and outside cabin, in the engine rotations of 800rpm, 2180rpm and 2500rpm. In each reading, 100 noise intensity values were automatically collected, over two minutes with the aid of a digital decibel meter device. The results were compared with the levels assumed by Annex 1 of the regulatory Brazilian standard NR 15, and it was found that the cabin was able to isolate the noise emitted by the engine and its external components in 15%, however, the internal noise reached 81dB(A). The cabin can attenuate external noise and offer a healthy working environment, however, in long working hours it is recommended to use personal protective equipment such as ear protectors.

Keywords

Ergonomics; agricultural tractor operator; workplace safety.

Introduction

The operator of agricultural machines and tractors can be affected by unhealthy working conditions (Poje et al., 2016), being subject to the direct influence of sunlight, dust particles, machine vibration and high noise levels (Gonçalves et al., 2019). Among the factors that harm the health of tractor operators, noise is classified as one of the main ones (Baesso et al., 2017; Menezes and Paulino, 2004; Veiga et al., 2021), as it provides constant exposure from the moment of machine activation, at the beginning of the journey, until the end of the working day (Silva et al., 2018).

There are few studies developed for the analysis of noise in machines and its consequences on occupational health (Cunha and Teodoro, 2006). Baesso et al. (2017), verified in an experimental noise analysis work with 22 agricultural tractors, that none presented levels below the regulatory standard, thus considering that all activity with non-cabined tractors need an ear protection system.

Noise-Induced Hearing Loss (NIHL) is one of the most frequent occupational health problems worldwide. The development of pathologies and the damage caused to the hearing aid is determined by the sound level, type of frequency, exposure time, noise power and operator vulnerability. Ear injuries caused by high noise levels do not present immediate results, but cumulative (Noronha, Travaglia Filho e Garavelli, 2005). The negative effects of noise are not limited to hearing, but emotional disturbances, fatigue, stress and cardiovascular problems are also verified (Silveira et al., 2007).

The regulatory Brazilian standard NR-15 of the Ministry of Labor and Employment establishes, through its annex 1, the noise exposure limit as a function of time, with the value of 85 dB(A) being the maximum noise level for a working day of 8 hours of exposure, thus, depending on the level and intensity, the standard establishes the need to use ear protectors and other personal protective equipment (Brasil, 2013).

Considering that the closed cabin of a tractor may not be efficient in isolating the operator from noise, the objective of this research was to evaluate the noise level transmitted by a cabin agricultural tractor, at the operating points inside the cabin and, in the peripheral external area, under different engine rotation regimes to compare the level exposure with current legislation.

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Materials and methods

The study was carried out in the municipality of Garça/SP in latitude 22°13'6.91"S, longitude 49°40'59.60"W, altitude of 655m. The tests were carried out in an open area, according to the NHO-01 standard (Fundacentro, 2001), in a place free from obstacles to avoid the influence of environmental noise in the data collection process.

A digital thermohygroanenometer device, model VA8021, duly calibrated, was used to monitor the environmental data. The average air temperature at the time of tests was 21ºC (294,15 Kelvin); the relative humidity equal to 41% and the wind speed to 1.2 m s-1. In the noise emission tests, a John Deere tractor, model 6110J, with a power engine of 81kW, with 1915 hours of work, was used.

The tests were carried out with the tractor on, at three different engine speeds (accelerations) of 800rpm (minimum idle speed), 2180rpm (rated engine speed) and 2500rpm (maximum engine speed). In each of the rotations, collections were carried out with the decibel meter inside the cabin, at 0.2m from the operator's ear (according to NBR 9999) and, outside the cabin, at 1, 2 and 3m away from the tractor at the four cardinal points. The noise was analyzed through a decibel meter model DL - 4200, micro processed, with a special protector (IEC 61672, Class 2), duly calibrated, operating under the compensation range of the "dB(A)" type with a slow response circuit (Slow). Data collection and test points were obtained according to the methodology described in the NBR-9999 standard (ABNT, 1987).

The experimental design was completely randomized (CRD), with 12 treatments, consisting of 3 engine rotations and 4 collection points around the tractor. In all tests, the tractor was static, at each sampling point, the total time for data collection was 2 minutes, obtaining the average value of 100 noise acquisitions by the decibel meter, automatically recorded in the device software.

The results obtained at each point were compared with the determination described in annex 1 of the NR-15 standard, which was used as a parameter for defining the tolerance limits for the physical agent noise in each position. The average results were treated through descriptive and parametric statistics. Normality test, analysis of variance and, when applicable, Tukey's test at 5% probability were performed.

Results and discussion

In Figure 1, results obtained at different collection points around the tractor and inside the cabin. In Figure 1.a, it is observed that the noises close to the operator's ear are at levels close to 60dB(A) when the tractor is at 800rpm engine, however, when the rotation was increased to 2180 and 2500rpm the levels of internal noise have increased significantly.

Figure 1 b. indicates that the greater intensity of the noise comes from the front of the tractor, a fact that can be related to the noise of the engine due to its frontal arrangement on the tractor. The noise levels with the engine at higher rotations reached 84dB(A), which indicates a value close to the limit established by the NR-15 standard. Silva et al. (2018) in an evaluation of noise levels in mechanized coffee operations, found levels above the regulatory norm in practically all agricultural operations.

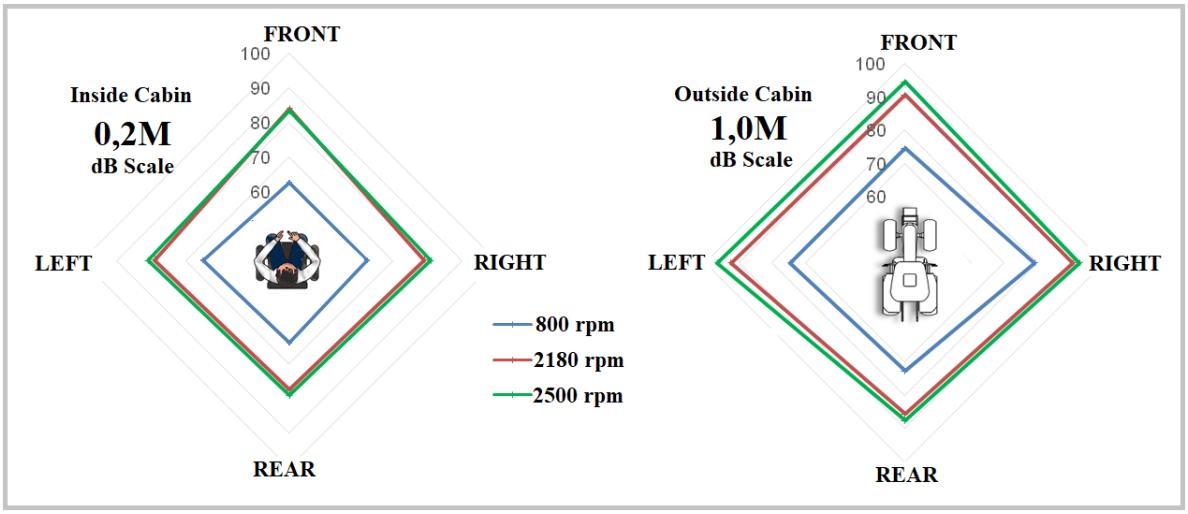

Figure 1. Dispersion of noise emitted at 0.2m inside the cabin and 1m in the external area at different points of the tractor.

The increase in engine speed led to an increase in the noise level at all evaluated points, indicating the relationship between noise and the adopted work regime. The data collaborate with those obtained by Alves et al. (2011) and Andrade, Santos and Sartori (2017). Annex 1 of NR-15 describes that the tolerance limit value allowed for daily exposure, in 8 hours of work, cannot exceed 85 dB(A), in present research, the noise in the internal area did not exceed the limit, but reached values very close to this. Between two and three meters away, the results obtained for the noise level showed little difference. The same happened with the noise differences obtained for 2180 rpm and 2500 rpm in the engine (Figure 2). Veiga et al. (2021) found noise levels above those allowed in the NR15 standard around tractors of different brands, and the safe distance to stay close to these machines varied between 3.5 and 6 meters.

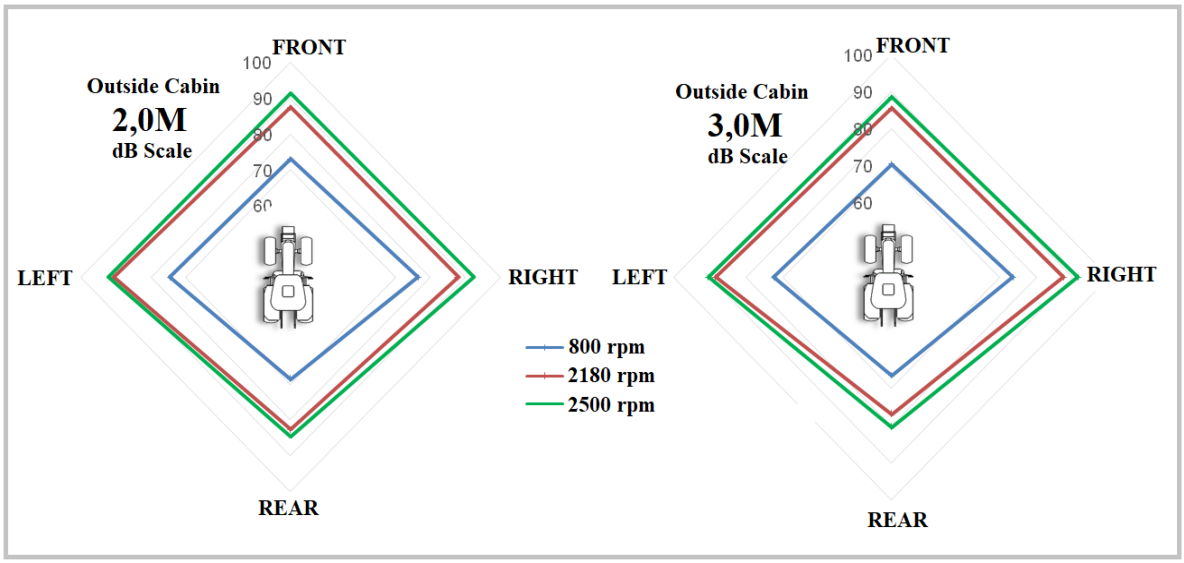

Figure 2. Dispersion of noise emitted at 2 and 3m outside of the tractor, in the external area at different points.

In the rotation of 800rpm, the noise did not exceed 85dB(A), in any of the evaluated points, indicating that the tractor at idle, without acceleration, does not offer work risk according to the regulations of the Ministry of Labor and Employment. However, at the speeds of 2180 and 2500 rpm, noises were emitted that exceeded the desirable limits (Figure 1b.; 2a.; 2b.), in these cases the exposure of workers cannot be greater than 2 hours and 40 minutes and 1 hour and 15 minutes, respectively, respecting the determined limits in annex 1 of NR 15 and making the use of ear protectors mandatory in these situations. The results collaborate with those obtained by Oliveira et al. (2020).

The results of this research corroborate those of Cunha and Teodoro (2006), who, analyzing the sound power levels as a function of the distance radius in tractors under different engine speeds, found that the sound power levels lost intensity as the distance from the machines, however, they found values higher than those recommended even at distances greater than 10m.

The results obtained in this research showed little variation up to 3 meters, however it is important to highlight that the decibel scale dB(A) is logarithmic, which allows inferring the differentiation in each differential of units obtained. The results obtained for this tractor model were similar to those verified by Baesso et al. (2017). Table 1 presents the result of the noise average test at each distance from the tractor.

Table 1. Test of averages for the noise presented dB(A) in the internal environment of the cabin and in different distances from the tractor (1, 2 and 3m) in the external area

	Inside Cabin	Outside Cabin						
	0,2m	1m		2m		3m		
rpm	ṁ dB(A)	Test	ṁ dB(A)	Test	ṁ dB(A)	Test	ṁ dB(A)	Test
800	63,49	Bc	75,12	Ba	73,12	Bab	70,75	Bb
2180	79,87	Ac	89,87	Aa	89,62	Aa	84,62	Ab
2500	81,12	Ac	92,75	Aa	90,12	Aab	87,75	Ab
C.V. (%)	4,65		6,49		6,76		7,12	

**Equal capital letters indicate equal means in the columns ($p<0.05$); Equal lowercase letters indicate equal means across the lines ($p<0.05$).

In absolute terms, the noise reduction is presented by up to 15% inside the cabin in relation to the external environment, showing the effectiveness of the cabin in reducing noise to the operator. The average noise values at 2180 and 2500 rotations did not show statistical difference, confirming the data trend observed in Figure 1a and 1b. The lowest observed averages were developed at 800rpm, with differentiation in relation to the other engine speeds. The results of the present research are in agreement with those obtained by Veiga et al. (2021), where the tractor cabin was able to attenuate the external noise, coming from the operation of the engine and other external components.

When observing the noise reduction in relation to the distance from the tractor (Figure 3), it is verified that the short distances do not allow a significant reduction in the noise emission level, a fact that is proven by the low coefficient of determination (r^2) found in 0.29, 0.27 and 0.23 for 800, 2180 and 2500rpm respectively.

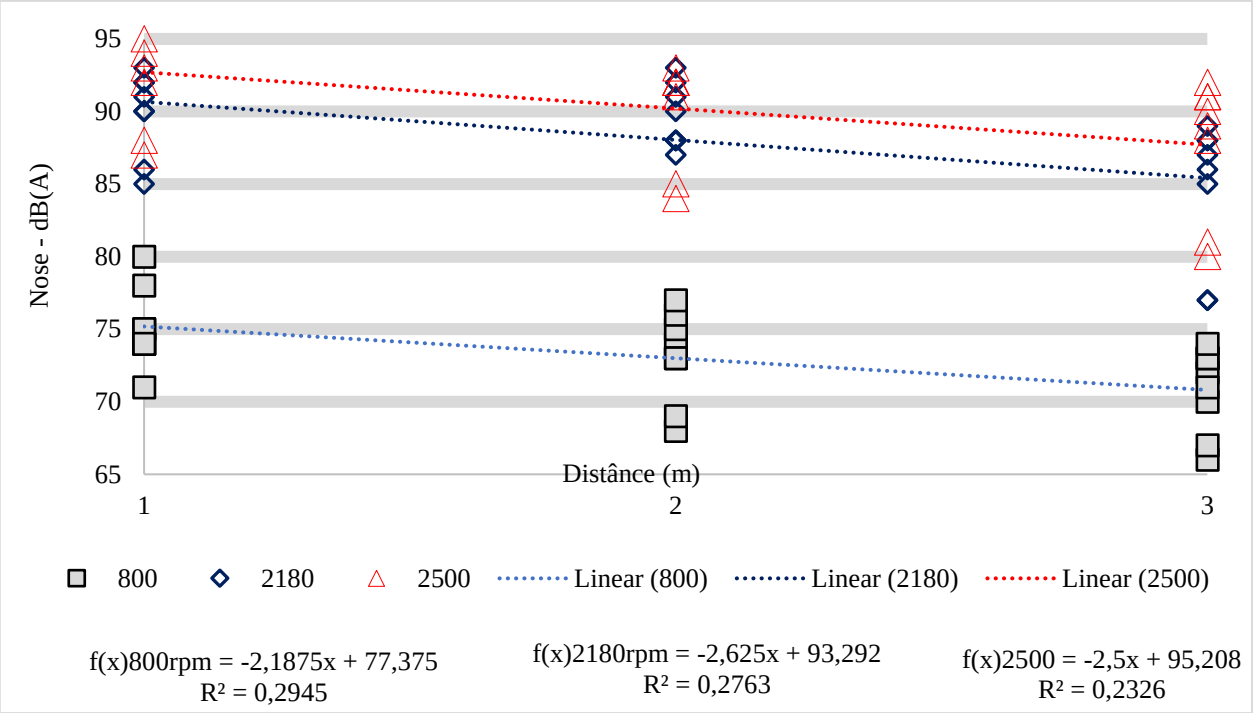

Figure 3. Coefficient of determination (r^2) for noise as a function of the external distance to the agricultural tractor.

The levels above that allowed by the NR15 regulation were established at speeds above 2180rpm, which represents the nominal or working speed of the machine. This fact indicates the need to use personal protective equipment also by other workers involved in agricultural activity who eventually transit around the machine.

The results show that the internal environment of the tractor cabin presents salubrious conditions according to annex 1 of the NR15 standard, however the use of personal protective equipment such as ear protectors can mitigate exposure to risks. Oliveira et al. (2020) obtained significant noise reduction rates as a function of the distance from the machine, however, the authors worked with a larger displacement scale. Gonçalves et al. (2019) stated that there is spatial dependence in the distribution of noise in the agricultural environment and indicated that up to 6 meters away, in the surroundings of a pigtail tractor, professionals must use ear protectors.

The use of personal protective equipment is essential to preserve the physical integrity of machine operators and should be used in short working distances of these (Damasceno et al., 2019; Poje et al., 2016; Oliveira et al., 2020) , even if the levels inside the cabin have reached levels below the critical values recommended by the NR15 standard, in a preventive way it may be interesting to use personal protective equipment (Baesso et al., 2017) in all operations with agricultural tractors.

Conclusions

The cabin allows for a reduction of up to 15% of external noise, complies with current legislation and represents a healthy working environment; however, during long working hours, the high engine speeds can raise the internal noise to values close to the maximum exposure tolerance limit, indicating that, even inside the cabin, it is recommended that the operator use the ear protector as personal protective equipment.

The noise has a positive relationship with the increase in engine speed. The tractor at idle speed does not present harmful noise levels at any of the evaluated points. However, from the rotation of 2180rpm, external noise levels present risks to operators in the peripheral environment of the machine.

References

Alves, A. D. D. S., Costa, F. R. L. D., Cortez, J. W., Dantas, A. C. D. S., Nagahama, H. D. J. (2011). Níveis de potência sonora emitidos por trator agrícola em condições estáticas e dinâmicas. Pesquisa Agropecuária Tropical, 41, 110-119.

Andrade, M., Santos, P., Sartori, J. (2017). Avaliação de parâmetros ergonômicos: ruído e temperatura no posto operacional de tratores agrícolas. Convergências: Revista de Investigação e Ensino das Artes., 10(19), 1-6.

Associação Brasileira De Normas Técnicas – ABNT. NBR 9999; medição do nível de ruído, no posto de operação de tratores e máquinas agrícolas. Rio de Janeiro: 1987.

Baesso, M. M., Modolo, A. J., Baesso, R. C. E., Fischer, C. (2017). Níveis de ruído emitidos por tratores agrícolas. Revista Brasileira de Engenharia de Biossistemas, 11(3), 229-238.

BRASIL. Ministério do Trabalho e Emprego. Portaria 3.214, de jul. 1978. Normas regulamentadoras de segurança e saúde no trabalho - NR 15: Atividades e Operações Insalubres. Brasília, 1978. Disponível em: < https://enit.trabalho.gov.br/>. Acesso em: 10 dez. 2020.

Cunha, J. P. A. R.; Teodoro, R. E. F. (2006). Avaliação do nível de potência sonora em derriçadores e pulverizadores motorizados portáteis utilizados em lavouras de café. Bioscience Journal, Uberlândia, v. 22, n. 3, p. 71-77.

Damasceno, F. A., Soares, C. M., Oliveira, C. E. A., Araújo, G., Ferraz, S., Saraz, J. A. O. (2019). Avaliação do Nível de Ruído Emitido por um Trator Agrícola Acoplado a uma Colhedora de Milho. Revista Engenharia na Agricultura, 27(5), 412-419.

Fundacentro. (2001). Fundação Jorge Duprat Figueiredo de Segurança e Medicina do Trabalho. Norma de higiene ocupacional: procedimento técnico: avaliação da exposição ocupacional ao ruído. São Paulo, 40 p.

Gonçalves, L. M., Ferraz, G. A., Oliveira, M. S. D., Barbosa, B. D., Silva, C. J. D., Ferraz, P. F. (2019). Characterization of noise emitted by a power tiller through geostatistics. Revista Brasileira de Engenharia Agrícola e Ambiental, 23, 223-228.

Menezes, J. S. R., Paulino, N. J. A. Efeitos do Ruído no Organismo: Manual de Avaliação e Controle do Ruído. 3ª Ed. LTr. p. 62-72. São Paulo. 2004.

Noronha, E. H., Travaglia Filho, U. J., Garavelli, S. L. Quantificação dos níveis de ruídos num estande de tiros da PM do Distrito Federal. Humanitates. 2005; 1.

Oliveira, G. S. A., de Oliveira Júnior, G. G., Rezende, R. N., de Ramos, L. E., Ramos, J. A., Ramirio, L. D., ... & do Valle Coutinho, P. R. (2020). Variabilidade Espacial do Nível de Ruído em um Conjunto Trator-Pulverizador sob Diferentes Rotações no Cafeeiro. Brazilian Journal of Development, 6(11), 86094-86101.

Poje, A., Potočnik, I. G. O. R., Danilović, M. I. L. O. R. A. D., Antonić, S. L. A. V. I. C. A. (2016). A case study of the impact of skidding distance on tractor operator exposure to noise. Baltic Forestry, 22(2), 357-364.

Silva, J. A. R. D., Oliveira Júnior, G. G. D., Costa, C. E. D. M., Silva, A. B. D., Gabriel, C. P. C., Putti, F. F. (2018). Occupational noise level in mechanized and semimecanized harvest of coffee fruits.

Silveira, J. D., Fernandes, H. C., Rinaldi, P. C. N., Modolo, A. J. (2007). Níveis de ruído em função do raio de afastamento emitido por diferentes equipamentos em uma oficina agrícola. Engenharia na agricultura, 15(1), 66-74.

Veiga, R. K., Gontijo, L. A., Masiero, F. C., Venturi, J. (2021). Análise e distribuição espacial do ruído no posto de trabalho do operador e nas proximidades de máquinas agrícolas e florestais. Ciência Florestal, 31, 43-65.