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ERGONOMIC EVALUATION OF AGRICULTURAL TRACTORS USED IN FORESTRY OPERATIONS

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ABSTRACT

The objective of this work was to evaluate farming machines adapted to forestry work and to verify if their characteristics meet the safety, ergonomics and working conditions necessary to maintain the health and safety of the operators. Thus, three farming tractors were selected, with a closed cabin and a minimum power of 73.5 kW, a widely used specification in the forestry sector. The following ergonomic parameters were considered: acess to the cab, cab dimensions, visibility, seat, controls and operation, work posture, cabin air conditioning, noise, lighting and maintenance aspects. The evaluations were based on the guidelines contained in the "Ergonomic Guidelines for Forest Machines" of the Swedish Forestry Research Institute, developed for forestry machines. The results showed that all the evaluated machines presented ergonomic standards below those indicated in all evaluated aspects, particularly related to access to the work station and difficulties during mechanical maintenance, besides the necessity of adopting forced postures during the working day due to operator's seats. It was concluded that the farming machines adapted for work in forest processes presented significant gaps in relation to the ergonomic aspects, which represents high and imminent risks of development of occupational diseases in their operators, as well as the predisposition to work accidents.

Palavras-chave:
Ergonomia
Saúde ocupacional
Mecanização florestal
Máquinas agrícolas
Produção florestal

AVALIAÇÃO ERGONÔMICA DE TRATORES AGRÍCOLAS UTILIZADOS EM OPERAÇÕES FLORESTAIS

RESUMO

Este estudo objetivou avaliar máquinas agrícolas adaptadas ao trabalho florestal e verificar se suas características atendem às medidas de segurança, ergonomia e condição de trabalho necessárias à manutenção da saúde e segurança dos operadores. Foram selecionados 3modelos de tratores agrícolas, cabinados e com potência mínima de 73,5 kW, especificação amplamente utilizada no setor florestal. Os seguintes parâmetros ergonômicos foram avaliados: acesso à cabine, dimensões da cabine, visibilidade, assento, controles e operação, postura de trabalho, climatização da cabine, ruído, iluminação e aspectos de manutenção. As avaliações tomaram por base as diretrizes contidas no "*Ergonomic Guidelines for Forest Machines*" do Instituto de Pesquisa Florestal da Suécia, desenvolvido para máquinas florestais. Os resultados apontaram que todas as máquinas avaliadas apresentaram padrões ergonômicos abaixo dos indicados em todos os aspectos avaliados, principalmente relacionados ao acesso ao posto de trabalho, dificuldades durante a manutenção mecânica e necessidade de adoção de posturas forçadas, decorrente das deficiências nos assentos dos operadores. Concluiu-se que as máquinas agrícolas adaptadas para trabalhos em operações florestais apresentaram significativas lacunas ergonômicas, representando elevado e iminente risco de desenvolvimento de doenças ocupacionais em seus operadores, bem como a predisposição para acidentes de trabalho.

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INTRODUCTION

With an area of approximately 8 million hectares of planted forests (IBÁ, 2019), combined with the favorable climate and soils, this important sector of the Brazilian economy has been experiencing constant growth, leading to increasing demands for forest-based products. To meet this growing demand, in a scenario where labor is increasingly scarce, the sector's competitiveness is increasing and the demands of globalized consumer markets are continuously increasingly, the mechanization of wood production activities became imperative for the sustainability of the forestry business.

Thus, there is a pursue in minimizing production costs, reducing dependence on labor, increasing productivity, reducing work accident rates and damage to the environment in addition to ensuring a continuous flow of wood supply to the consumer units (SCHETTINO *et al*., 2017). The mechanization of forestry activities in Brazil, in most cases, used imported machines and with high acquisition and maintenance costs, which are not always accessible to all companies and, particularly less, to small wood producers.

These financial factors have led the national mechanical industry to develop, adapt and test several models of machines with different principles, whether from farming tractors or machines developed for civil construction, among others; and this has been the alternative found by forestry companies, in addition to independent wood producers or linked to companies through forestry development contracts, for the mechanization of their forestry activities.

According to Rozin *et al*. (2010), with the operation of these adapted machines, an operator is exposed to several environmental factors that will directly interfere with his or her performance and his or her health and safety, such as, for example, the position of the body when accessing the cabs and the workstation; position of controls and levers; climatic conditions, such as extreme temperatures, solar radiation, ventilation and humidity problems; level of sound intensity produced by the engine and / or transmission of the machine; particles suspended in the air like dust and exhaust gases; seat vibration caused by the machine and terrain irregularities.

All of these factors are contrary to the basic principle of ergonomics, which is to adapt work to human beings (IIDA, 1995). In addition, according to the author, in an ideal situation, ergonomics should be applied from the initial stages of the design of a machine, environment or workplace. They must always include the human being as the main component.

To achieve this objective, the Forestry Research Institute of Sweden (SKOGFORSK, 1999) has developed a guide to provide guidance on ergonomic issues for manufacturers, buyers and users of forest machines, in order to support the development of safe, easy to be used and maintained machines. This, in turn, offers operators a better chance of preserving their general health and well-being (SKOGFORSK, 1999).

Thus, the characteristics of the operators must be considered together with the characteristics of the environment and mechanical parts, in order to mutually adjust to each other, which are premises that, in general, have not been observed in the designs of machines adapted for forestry activities.

Thus, the objective of this study was to evaluate farming machinery adapted to forestry work and to verify whether its characteristics meet the safety, ergonomics and working conditions necessary to maintain the health and safety of operators when performing forestry activities.

MATERIAL AND METHODS

The evaluated machines were chosen at random and according to their availability, between December 2018 and June 2019. For this purpose, it was assigned as a criterion that the machines had at least 73.5 kW (100 hp) and that they had closed cabins and with air-conditioning, a standard widely used in the Brazilian forestry sector. In order to avoid trends, tractors from different manufacturers were selected and the following machines were evaluated (Figure 1):

- BX110 – Farming tractor, Agrale brand, BX110 model, 80.8 kW power, 4x4 version, with original climatized and closed cab, manufactured in Brazil in 2013.
- 6100J – Farming tractor, John Deere brand, 6100J model, com 73.5 kW power, 4x4 version, with closed and climatized cab, manufactured in Brazil in 2017.
- BM100R – Agricultural tractor, Valtra brand, BM100R model, with 73.5 kW of power, 4x4 version, with original factory closed and air-

conditioned cabin, manufactured in Brazil in 2019

All the steps of this study were carried out in the northern region of Minas Gerais State, in the municipalities of Montes Claros and Francisco Dumont, within the geographical coordinates 16°44'06"south latitude and 43°51'43" west longitude and, 17°17'41"south latitude and 44°14'32" west longitude, respectively.

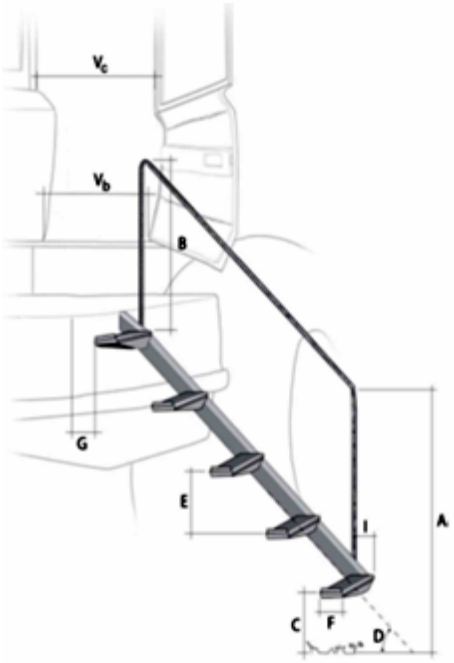
The machines were qualitatively and quantitatively evaluated, based on the methodologies proposed by Gellerstedt (2006) and by means of ergonomic guidelines contained in the ergonomic classification manual "Ergonomic Guidelines for Forest Machines" (SKOGFORSK, 1999), developed for forest machines. These ergonomic guidelines are applicable to all off-road machines that are equipped with cabs, weigh more than two tons and are used in forestry activities, which means that the evaluated agricultural tractors are included and are liable to be evaluated by this methodology.

The following items were evaluated: access to the cab, cab dimensions, visibility, seat, controls and operation, working posture, cab climate, noise level, lighting and maintenance aspects. These characteristics are described below.

To evaluate the assess to the workstation, the following variables were measured: position, step size, height of the first step to the ground, distance between steps, depth of steps, height and width of the access door to the cab. The measurements were performed according to the parameters specified in Figure 2.

(1) (2) (3)

Figure 1. Tractors evaluated in this study, where: (A) Agrale BM110; (B) John Deere 6100J; and (C) Valtra BM100R



	Item	Reference (cm)
A	Ground to the handrail	85-130
B	Step to handrail	85-100
C	Ground to the first step	≤ 40
D	Maximum pitch	≤ 50º
E	Distance between steps	20-30
F	Step depth	≥ 24
Va	Step width	≥ 40
G	Last step to the cab ground	≥ 15
I	Distance from the first step to the handrail insertion	≤ 63
Vc	Door width – middle	≥ 65
Vb	Door width – lower	≥ 45
Vi	Door height	≥ 170

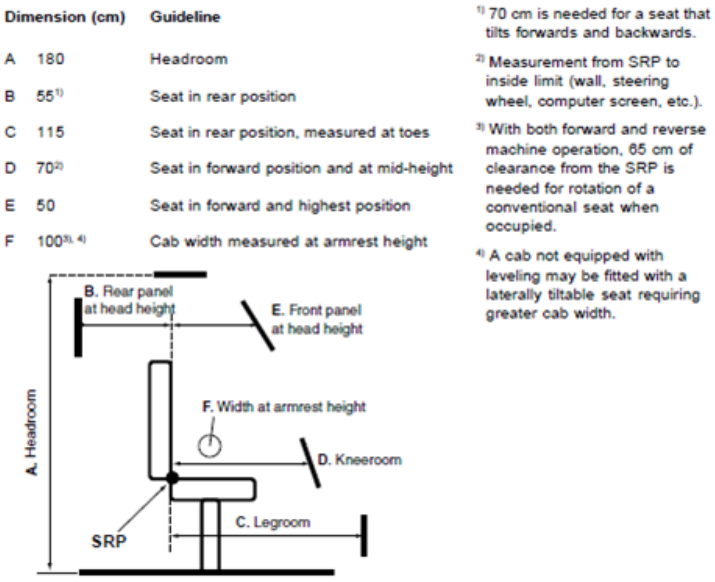
Source: Skogforsk (1999)

Figure 2. Measurement parameters and reference for the cab access of the machines

Using a measuring tape, the following variables were obtained: length, width and height of the cab (Figure 3). In the qualitative analysis, the presence of protrusions, the state of conservation and the type of material used in the manufacturing were observed and evaluated.

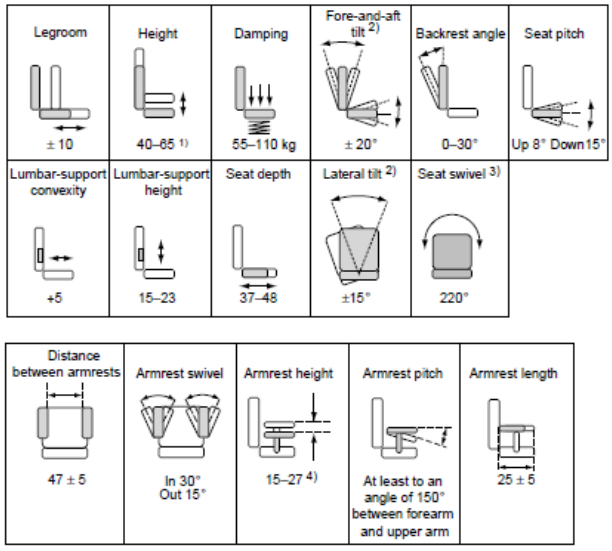
The evaluation of the glass dimensions and the observation of the visibility of the outside of the machine were made from the operator's seat point. Visibility was assessed using qualitative criteria, focusing on the view from the ground and upwards, absence of reflections and blurred glass, no obstruction by implements or parts of the machine, among others.

The variables length and width of the seat, height of the lower and upper backrest, length and height of the armrest, angle of the seat-backrest, angle of rotation and variation of the horizontal distance, according to Figure 4, were obtained by using tape measure and protractor.



Source: Skogforsk (1999)

Figure 3. Parameters and references for dimension of the machines' cab



Source: Skogforsk (1999)

Figure 4. Parameters and references for dimensions of the seats of the machine operators

The controls were evaluated in relation to the spatial configuration, color, position to hold and strength magnitude according to the frequency of use. The distances of the controls at the machine workstation were obtained from the seat reference point with the aid of a measuring tape. In this section, it was evaluated the operator's posture and movements in the workspace, which are influenced by the design of the cab, the seat and the controls, and the manipulation of the controls. Measurements of postures and movements performed by the operator were performed with the aid of a measuring tape.

Regarding the cab climatization, it was checked the arrangement of the controls and the possibility of temperature and air speed adjustments, as well as the observation of the thermal sensation inside the cabs.

The assessment of exposure to occupational noise was performed using an equivalent noise-level meter (dosimeter), 01dB-Metravib brand, model Wed007, level of compensation A and in slow-response circuit. The microphone was installed close to the operators' ears, using the methodology of Occupational Hygiene Standard (OHS) No. 01 of the Jorge Duprat Figueiredo Foundation of Occupational Safety and Medicine - FUNDACENTRO, linked to the Ministry of Labor and Employment - MTe (FUNDACENTRO, 2001). The obtained values were compared with the maximum exposure limits determined by Regulatory Norm (RN) No. 15 - Unhealthy Activities and Operations of the MTe, in its Annex 1 (BRASIL, 1978).

The evaluation of the lighting of the machines was carried out by counting the number of headlights, existence of directional controls of the light beams and calculations of viewing distance from the work points from the operator's seat, with the use of a measuring tape.

Visual assessment of maintenance points was carried out by observing whether there was a need to work in difficult positions, climbing on the machine with the risk of slipping, working under the machine, physical effort, heavy work, harmful liquids, handling of slippery, hot and dirty pieces and if there was the possibility of contact with sharp objects or with hot steam or liquids.

According to Skogforsk (1999), all items are measured and evaluated in their respective sections and classified in one of the five ergonomic classes, according to the ergonomic profile: A, B, C, D and E, ranging from A (best ergonomic condition) up to E (worst ergonomic condition), as shown in Chart 1.

For each evaluated item, the ergonomic classification received a score, ranging from 1 for classification A to 5, for classification E. For the calculation of the final ergonomic classification of each evaluated machine, the respective averages of all evaluated items were considered.

Chart 1. European Ergonomic Classification for Forest Machines according to the Principles of Ergonomic, Health and Safety of the Operators

Ergonomic classification	Description
A	It presents high productivity throughout the year, in all types of terrain and forest conditions. High level of security. Easy and safe maintenance.
B	It presents high productivity, but only in better conditions than in the previous class (e.g.: flat land, forests of very high productivity and / or favorable climatic conditions). Same level of safety, however, at lower standards than in class A.
C	It presents high productivity in less time, in better soil and forest conditions and, or, in better climatic conditions than in class B. Same level of safety, but, on the other hand, in less high standards than in class B.
D	It hardly presents high productivity, in any condition of soil and forest and, or, in climatic conditions. It presents low safety standards, with risk of injury to the operator.
E	The machine does not meet European safety standards and, or, it has serious flaws, capable of exposing the operator to imminent risk of injury. The machine must not be used until the problems are fixed and classified within the previous classes.

Source: Adapted from Skogforsk (1999)

RESULTS AND DISCUSSION

The results of the access-to-the-cabin assessments of the different machines evaluated are shown in Table 1.

The measurements of the BX110 tractor diverged in relation to the cab evaluation, when compared with the reference values. When entering and leaving the machine, the operator needs to perform some irregular movements, for example, the impossibility of using the steps without three support points (BRASIL, 2012). The availability of the handrail was verified, but it had gaps in the construction and could be used, but with some difficulties. The steps are made of metal and have no exposed right angles, but presented lower width and depth measurements than the expected. The cabin door was smaller than the recommended, and a taller operator can only get on the cabin with some difficulty.

In the same direction, the 6100J tractor also diverged in relation to its cab. The handrail is available, but with gaps in its construction which creates difficulties in its use. The steps proved to be firm and well located, but their width and depth measurements did not reach what was recommended according to the reference ergonomic classification manual for this study. The cab door is easy to handle and remains open when the machine is tilted or exposed to winds; however, it does not meet the recommended measures.

In turn, access to the cab in the BM100R tractor showed greater divergences in relation to the recommended dimensions. The dimensions of the width and depth of the steps are smaller than the recommended; the cab door is easy to handle and remains open when the machine is tilted. In addition, the handrail was inadequate in terms of its measures, creating difficulties for its correct use.

According to Fernandes *et al*. (2010), the position and characteristics of the access roads to the machine's operating station can often be the cause of the accidents. The dimensions of the steps, the distance between them, the height of the first step to the ground and the vertical distance of the last step to the machine platform must be designed according to the anthropometric variables of the machine operators. In addition, badly designed access can also be an obstacle for older operators (SKOGFORSK, 1999). In fact, this seems to be a recurring problem in the forestry sector, according to the results found by Minette *et al*. (2008), when evaluating 13 forest harvesting machines and concluding that all had access variables outside the range of the recomended values.

As for the cab, all evaluated tractors had closed cabs, which provides protection against objects that could be projected from the ground. In addition, it was found in all of them that there was enough room to accommodate a first-aid kit or personal

Table 1. Dimensions of the access to the cabs of the evaluated machines in comparison to the standards set in Skogforsk (1999)

	Item	Recomended value (cm)	Observed value (cm)		
			BX 110	6100J	BM100R
A	Ground to handrail	85-130	150*	130	130
B	Step to handrail	85-100	126*	75*	70*
C	Ground to the first step	≤ 40	46*	55*	65*
D	Maximum pitch	≤ 50º	90*	75*	45
E	Distance between steps	20-30	30	32*	25
F	Step depth	≥ 24	11*	19*	10*
Va	Step width	≥ 40	30*	34*	33*
G	Last step to the cab ground	≥ 15	23	30	25
I	Distance from the first step to the handrail insertion	≤ 63	100*	75*	65*
Vc	Door width – middle	≥ 65	88	65	75
Vb	Door widht – lower	≥ 45	43*	35*	50*
Vd	Door height	≥ 170	140*	144*	148*

Note: Values marked with * are outside the recommended value range for the item.

items. All had only one emergency exit, located in the rear window, and with adequate dimensions.

Overall, all the evaluated tractors had cabins with smaller dimensions than those recommended by the reference standard of this study, a fact that raises concern from the perspective of ergonomics (Table 2). The correct dimensioning of the workstation should allow enough room inside the cab, so that the operator, regardless of his or her physical constitution and muscle mass, can adopt comfortable working positions. To avoid fatigue, the operator must be able to sit in comfort, adopting a correct posture, especially with regard to the use of muscles and joints, avoiding twisting, lowering and other uncomfortable movements (SKOGFORSK, 1999).

All the evaluated tractors showed satisfactory results in relation to the workstation, as from the seat, the operator can view the floor in at least 2 meters away from the wheel and 5 meters from the front of the machine. As it has a large glass area in the front, rear and sides, the cab has good visibility, which means that the operator does not need to change position to visualize the work area. It is worth mentioning that, in all cases, the cleaning of the windows was deficient due to the absence of wipers on the side and rear windows, requiring it to be manually performed.

According to Minette *et al*. (2008), with regard to visibility, the ideal situation is that the forest machine operator has a clear view of the operational area without the need to adopt incorrect work postures, which can cause tension in the muscles, initially resulting in fatigue and pain and, in the medium and long term, in musculoskeletal disorders.

In all the evaluated machines, the operator's seat adjustment levels did not meet what was expected for forestry machines, where the leg room was less than 10 centimeters, compared to the ideal of at least 24 centimeters, according to the reference standard. No tractor showed the possibility of tilting the backrest. In addition, it was observed deficiencies in their height, depth and spacing between the armrests. Further, on the BM100R tractor, in addition to the flaws already mentioned, the seat presents a high level of noise during the operation of the machine, making its operation somewhat uncomfortable.

When an operation can be performed by a seated person, this seat must have been designed, constructed and with dimensions that are suitable for him or her and the task. There must be an inclination between seat and the upper backrest greater than 90 degrees, to force the trunk against the backrest, in order to make full use of the seat (TEWARI; DEWANGAN, 2009). Also, according to Skogforsk (1999), the seat must have height, distance and length adjustment and the armrests must be adjustable in height. Such seat and armrest

Table 2. Dimensions of the evaluated machines in comparison to the standards established in Skogforsk (1999)

	Item	Recomended value (cm)	Observed value (cm)		
			BX 110	6100J	BM100R
A	Space for the head	180	146*	137*	160*
B	Rear seat	55	12*	30*	35*
C	Forward-Backward tilt	70	--	--	--
D	Space for the feet	115	95*	72*	60*
E	Space for the knees with seat leaning forwards and half-height up to wind blocker	83	64*	35*	63*
F	Seat leaning forwards at the highest position	65	31*	85	85
G	Width of the cab measured at the armrest height	100	120	143	116
H	Length of the cab measured at the armrest height	--	162	150	--

Obs.: Values marked with * are outside the value range recomended for the item.

variables must be dimensioned according to the anthropometric standards of the local workers.

The machines evaluated in this study also showed some flaws regarding controls and instruments, since their location must be designed so that the arms reach them within their normal range of action in a way that the operator does not have to bend the back or move the body, thus avoiding greater fatigue and more time in the execution of tasks (BARRETO *et al*., 2013; SILVA *et al*., 2014). In relation to the commands moved by the legs, they may be more demanding of strength, as long as the ideal position is observed that allows the exact movement (MERINO *et al*., 2012). The issue of non-conformity of controls and instruments in agricultural tractors was clearly addressed by Rozin *et al*. (2010) who, when analyzing 35 operating stations of 101 models of national agricultural tractors, concluded that only 23.1% of these operating stations met the current regulations.

Also, none of the evaluated machines presented any mechanism that prevents an accidental activation of the controls when leaving or entering into the cab, which suggests a predisposition to the occurrence of accidents

Regarding the work posture, all the evaluated machines again showed deficiencies. Postural difficulties for operators taller than the average height, as well as insufficient regulation of the seat and controls and room for the feet, factors capable of providing uncomfortable postures during the machine operation.

According to Gellerstedt (2006), the most frequent incorrect postures are those in which the individual sinks into the seat or when he or she leans towards one side, stressful and harmful to health positions. When the worker is seated, the seat should facilitate and not compel the operator to maintain a good posture. Also, according to the author, the seat must be designed to eliminate the discomfort caused by unnecessary pressure on the lower thighs and by the restriction of blood flow in the buttocks, due to the poor distribution of the individual's body mass. Sitting for a long time in the same position causes unpleasant feelings. The seat design must allow the operator to assume different positions during the work period, without losing the necessary support. When some of these principles are neglected, there is a tendency of discomfort, which may cause considerable inefficiencies and dissatisfaction at work, as well as the appearance of occupational diseases.

As the cab of all evaluated machines is closed and with air-conditioning, no problems related to thermal discomfort during operation were identified. In all cases, the air conditioning is adjustable in speed and temperature, with individually adjustable controls and easy to operated, allowing the maintenance of the temperature within the thermal comfort range which, according to Iida (1995), is limited by temperatures between 20ºC and 24ºC , with air relative humidity between 40% and 60% and moderate air speed at the order of 0.2 $m.s^{-1}$.

Climatic conditions have a great effect on the performance of the operator's work. The conditions necessary for the existence of comfort correspond to a neutral thermal state, in which most workers have no reason to complain about the environment. Such a condition exists when there is no excess of heat or cold, the humidity is not too high or the air is too dry, strong wind currents do not occur and the atmosphere is not muffled. When the weather is unfavorable, indisposition and fatigue occur, therefore decreasing efficiency and increasing the occurrence of accidents. When the worker is forced to withstand high temperatures, the labor performance drops. The risks include not only a decrease in the performance but also prostration, due to heat or sunlight (GRANDJEAN, 1982).

The noise assessment showed that the operators of the three machines are not exposed to high noise doses, with values found below the action limit stipulated by the NR-15, which is 80 dB(A) for 8 hours/day (BRASIL, 1978). Such a situation does not expose operators to undesirable health effects caused by noise, such as tinnitus, increase in blood pressure and heart rate, insomnia, stress and irritability, in addition to NIHL - Noise-Induced Hearing Loss, characterized by reduced hearing acuity due to prolonged and irreversible exposure (AYBEK *et al*., 2010; GUEDES *et al*., 2010).

It was observed in all evaluated machines that from the cabin seat, the lighting lamps allow a good general visibility, do not cause eye strain and faithfully reproduce important colors. On the BX110 tractor, the lighting system can be

switched off in groups, but not individually, as well as a precise targeting to a specific point is not possible. In the other tractors, the lighting system can be turned off in groups and also individually and, it is also allowed a precise direction towards a specific point. This finding allows us to state that the evaluated machines, although with some restrictions, allow night work without any harm to the health and safety of the operators.

According to Iida (1995), the correct lightning design contributes to increase job satisfaction, improve productivity and reduce fatigue and accidents. The factors that influence the discrimination are: light quality, exposure time (depends on the size, contrast and level of illumination of the object), contrast between figure and background (difference in brightness between figure and background), glare (produced by presence of lights, windows or excessively bright areas in relation to the general level of the environment, to which the eye was accustomed) and visual fatigue (caused by the exhaustion of the small muscles connected to the eyeball, responsible for the movement, fixation and focusing of the eyes).

In all cases, the machines did not have sharp corners neither sharp edges. The batteries are located outside the cab and they are easily accessible. There was a significant deficiency in the access to the maintenance points. This condition exposes mechanics to the risk of accidents and the development of occupational diseases, since the maintenance of forest machines in the field is usually carried out in adverse conditions (weather, sun, rain, day or night). Also, the mechanics can adopt inadequate postures to reach a certain part of the machine; climb and work under the machine; perform excessive physical effort; lift heavy materials; come into contact with harmful and dangerous liquids; and handle slippery, hot and dirty parts of the machine.

Hence, the frequency of lower back pain and tendonitis in people who perform forest work, both in a sitting and standing position, is a major factor in the repeated and prolonged absenteeism of the worker, and causes difficult problems for their professional reclassification (KISNER; COLBY, 2009). The frequency of these disturbances leads to the suspicion of an incorrect adaptation of the machine to the man, as well as incorrect work postures by workers. The incorrect planning of a work system, as well as the equipment, tools and auxiliary means, imposes excessive and unnecessary demands on the worker, causing problems with low back pain, tendonitis, comfort, early fatigue, productivity and incidence of errors in the work execution (FIEDLER *et al*., 2011).

After calculating the scores for the items evaluated, the BX110, 6100J and BM100R machines received, respectively, the following score: 2.9, 2.8 and 2.8, which is equivalent to the general classification C. The results of the ergonomic evaluations of the machines analyzed in this study are shown in Chart 2.

According to this classification, all evaluated machines widely used in forestry and silviculture operations and harvesting are only capable of presenting high productivity in better soil and forest

Chart 2. Results of ergonomic classification and evaluation of the analyzes machinery

Item	BX110	6100J	BM100R
Access to the cab	D	D	D
Cab	B	B	B
Visibility	B	B	B
Operator's seat	C	C	C
Machine control	D	D	D
Noise	A	A	A
Operation posture	C	C	C
Climatization	B	B	B
Illumination	C	B	B
Maintenance	E	E	E
OVERALL CLASSIFICATION **	**C**	**C**	**C**

** According to criteria set by Skogforsk (1999).

conditions and, or, in adequate climatic conditions; however, with low levels of safety and great risk of developing occupational diseases in its operators.

The workers' illness process is related to the way the work is performed (SILVA *et al*., 2014). According to Silva *et al*. (2009), in the forestry sector, many labor situations do not contribute to the promotion and maintenance of the health of the worker, a critical situation in the mechanization of forest activities, characterized by requiring operators to perform repetitive movements and maintain asymmetrical postures for prolonged periods, keeping an accelerated rhythm of work.

In the forestry sector, particularly in mechanized activities and because of the inadequacy of work stations, long working hours and the lack of work organization led occupational diseases to occupy a prominent place in concerns regarding the health and safety of workers (TEWARI; DEWANGAN, 2009; SILVA *et al*., 2013; SILVA *et al*., 2014; ALMEIDA *et al*., 2015; SOUZA *et al*., 2015). Such a finding is a clear demonstration that this risk group has low tolerability, with substantial risk, requiring actions to reduce its impact on operators who work in such activities (SCHETTINO *et al*., 2019).

CONCLUSIONS

- In the conditions in which this work was carried out, it could be inferred from the analyses that:
- Farming machines used in silviculture forestry and harvesting operations have deficient ergonomic standards in almost all evaluated aspects.
- The main inconsistencies presented were related to access to the workstation and difficulties during mechanical maintenance, in addition to the need to adopt forced postures during the working day due to deficiencies in the operators' seats.
- All machines evaluated in this work received a C ergonomic classification, indicating high productivity only in better soil and forest conditions and, or, in favorable climatic conditions, with a medium safety standard, presenting a risk of damage to the health of operators.
- There is a great and imminent risk of developing occupational diseases in the operators of these machines, in addition to the risk of accidents.

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