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TRACTOR NOISE EXPOSURE LEVELS IN EGYPTIAN FARMS

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ABSTRACT

Tractor noise exposure levels were measured for three different tractors power category I, II, and III. The tests were performed on different ground surfaces of asphalt, concrete (compressed hard soil), and normal crops field. The influence of engine speeds, ground configurations, and gear selections on noise exposure levels were determined. An average increase of 3.76 and 6.8 dBA was measured for engine speed changes from 1200 to 1500 rpm and 1500 to 2000 rpm respectively. The average sound level decreased as the top layer changed from concrete to asphalt and then to normal crops field. Change of gear selection from I to II and from II to III led to increase the average sound levels by 2.9% and 6 % respectively.

Results of the noise exposure measurements indicated the need for using a hearing protection aids specially for those workers accompanying the attached equipment for the tractors under study, since noise exposure levels had exceeded the permissible limit of 90 dBA for 8– hours work day which reached 93.7, 90.2, 90.8, 91.5, 83 dBA at driver seat, the front side, the left side, the right side and rear side respectively for Landini tractor (65.6 kW). While for Nasr tractor (48.5 kW) were 98.4, 93.7, 94, 94 and 92 dBA respectively for the mentioned positions. Also, for the Doedang tractor (26 kW), the noise values were 41.5, 53.8, 55.9, 55.6, 39 dBA respectively for those positions. Tractor's cap should also be used according to the standard specification of Occupational Safety and Health Administration (OSHA).

INTRODUCTION

Noise is recognized as a form of pollution. It is a public health hazard causing hearing impairments and a nuisance causing psychological stress. Many farm tractors are still charactracterized by noise levels sufficient to constitute a chronic health hazard for drivers and machinery operators.

Domenico and Matteo,(2000) stated that noise in the agricultural environment is not a new hazard. From 1981 to 1983 in the United States of America, the National Institute for Occupational Safety and Health (NIOSH) conducted the National Occupational Exposure Survey (NOES), to provide data descriptive of the occupational safety and health conditions in the USA. As a results of the survey NOES, workers were considered to be noise-exposed if the noise levels were 85 dBA or greater, regardless of the exposure duration.

Goering *et al,*(2003) considered that noise levels are the summation of rotating and reciprocating parts, structural vibrations, gases, and fluid flows, all of which are transmitted either through the machine structure or through the air. They also added that, vibrations in the frequency range of 1 to 50 Hz can adversely affect humans. Thus, the engineer has the challenge to design mechanical components to limit the levels of sound energy, machine vibration, and chassis motion to acceptable values for operator comfort and efficiency.

Goglia (1997) studied the problem of sound and vibration measurement and the procedure of results evaluation is also discussed. Forestry machine operator's are usually exposed to sound and vibration. Sound measurement procedure is defined in several International Standards. All procedures are divided into two groups: the procedures that define measurement of noise at the operator's position and the procedures that define measurement of airborne noise emitted by earth-moving machinery in the environment. The risk of noise-induced hearing damage is determined by: sound level, frequency and exposure time. The exposure limit of equivalent sound level reaching the operator's ear during a typical working day is in Croatia 90 dBA which is too high an exposure limit. It is known that the noise-induced hearing damage is possible if the equivalent sound level exceeds 85 dBA during a typical working day. Exposure to vibration can be divided into two separate areas: the whole body vibration which exposes the whole human body and the hand-arm transmitted vibration which exposes the hand, arm and shoulder. Further, also the whole body vibration can be divided into two frequency ranges. The frequency range from 0.1 to 0.63 Hz is known as the motion sickness frequency range. The frequency range from 1 to 80 Hz is known as the whole body vibration. Whole body vibration can influence health, comfort and performance. The sensitivity to whole-body and hand-arm transmitted vibration has been standardized. The sensitivity to hand-arm transmitted vibration varies depending on which part of the body is considered. To evaluate the influence of vibration on the human body four parameters have to be considered: vibration level, frequency characteristic of transmitted vibration, direction, and exposure time.

Kessler *et al.,* (1990) landscape gardeners operate many noisy horticultural and construction machines. Measured time weighted av. (TWA) noise exposures up to 103 dBA in landscape gardening and up to 101 dBA in landscape preservation and conservation qualify the workplaces of the landscape gardeners as "noise areas". Audiometric examinations of 36 municipal gardeners revealed 17 cases in which bone conduction hearing losses were considerably higher than the age related hearing losses specified by other West German studies.

Goering *et al.,* (2003) found that, noise is acoustic sound, which is mechanical vibrations in gaseous, fluid, or solid media. Sound is characterized by frequency, amplitude, and phase. The frequency range of the human ear extends from as low as 16 Hz to as high as 20,000 Hz; however, few adults can perceive sound above 11,000 Hz.

General-purpose sound measuring instruments are normally equipped with three frequency weighing scales, A, B and C. these scales approximate the ear’s response characteristics at different sound levels. Nebraska OECD tractor test data are reported in decibels, using the A weight scale, and written as dB (A). Design for noise control, however, requires more detailed analysis of sound spectrums. Sound analyzers measure sound levels in bandwidths ranging from octaves to only a few hertz in width.

The official guideline for noise exposure in the United States is based on the Occupational Safety and Health Agency (OSHA) Walsh-Healy Act. Table 1 shows current acceptable levels. Note that for exposure eight hours

per day, the sound level should not exceed 90 dBA. For shorter exposure times, higher levels of sound can be tolerated. These criteria were developed for factory worker environments. Application to off-road vehicle operators needs judgment because of intermittent, variable-intensity noise and seasonal variations in daily exposures. Nebraska OECD Tractor Test 1678, tractor with cab, the sound level at 75% load in 7th gear was 73.0 dBA at the operator's seat. For the bystander test in the 12th gear, 82.5 dBA was reported. Bystander distance is 7.5 m, measured in a direction normal to the centerline of the travel path.

Table1: Occupational Safety and Health Act (OSHA 1980) noise criteria.

Duration per Day, hours	8	6	4	3	2	1.5	0.5	0.24 or less
Sound Level, dBA [1]	90	92	95	97	100	102	105	115

Note: Exposure to impulsive or impact noise should not exceed 140 dB peak sound pressure level.

1. Sound level meter using A-scale, slow response.

Contrary to popular understanding, use of hearing protection has a minimal effect on communication. In high noise level environments (greater than 85 dB), hearing protection actually improves the listener's ability to understand speech (Berger, 1996). Hearing protection is most likely to interfere with communication among workers with hearing loss in noise levels less than 90 dB (Suter, 1993).

MATERIALS AND METHODS

The present study was carried out to measure the noise levels in surrounding area of the agricultural machinery operators workplace, The results should be considered during design of a new agricultural machinery to limit the levels of sound energy, machine vibration, and chassis motion to acceptable values. This in turn will lead to more comfort and efficiency for the operator, and to determine if there is a necessity to use the hearing protection devices during machine operation, or to built a protection cabin for the tractor. Experiments were conducted at the El Bostan research station, Nobaria during 2003. Three different tractors (Landini, Naser and Daedong 4 WD) were used in the investigation. The technical specifications of the three tractors used in this study are summarized in the following: -

Specification	Landini	Nasr	Daedong
Max. pto, kW	65.6	48.5	26
Engine	4 cylinder Perkins/AT. 4-236	4 cylinder	3 cylinder 3A165D

Power take off, rpm	540/1000	540 / 1000	540/2000
Tires and wheels Front Rear	900-16 18-4R 34	6.5/20 14/30	8-16 13.6-24
Total weight, Kg	3800	2300	1350

The following parameters were taken into consideration: -

1. Three different engine speeds (1200, 1500 and 2000 r.p.m).
2. Three different ground surfaces (concrete, asphalt, and normal crop field).
3. Three speed selection (gear I, II and III).

Digital Sound level meter (model SL 130) Pacer Industries was used for measuring the noise level in dBA. General-purpose sound-measuring instruments are normally equipped with three frequency-weighing scales, A, B, and C. These scales approximate the ear's response characteristics at different sound levels.

Effect of engine speed on sound levels was recorded at 5 position (driver seat, the front side, the left side, the right side and rear) around each tractor. The sound sensor was placed at a distance of 50 cm from the tractor while the tractor at rest position. The effect of gear selection and engine speed were carried out on three different ground surfaces in dry conditions of asphalt, concrete, and normal crops field (corn residues):

Asphalt: average type rough surface, Concrete: cement type rough surface, Crop field: regular crop field, sandy soil as tested 52.8% sand, 41.1% fine sand 4.1% silt and 1.7% clay at 30 cm depth.

The sound levels were measured while tractor movement (100 m track length) at those positions “driver and rear position” respectively, to have an indication about effect of engine speed, ground configuration and gear selection on sound level.

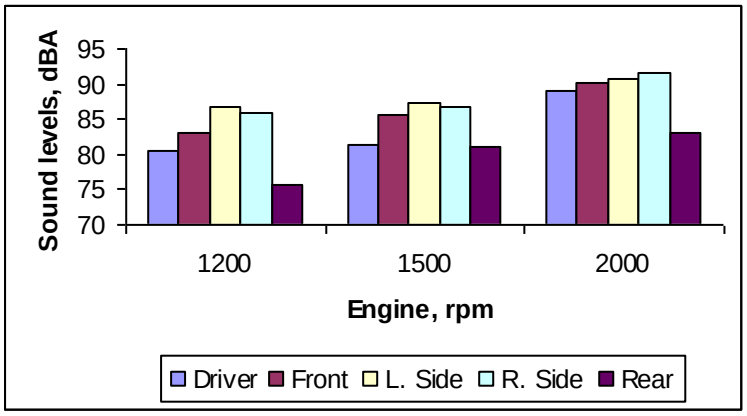
RESULTS AND DISCUSSION

Effect of engine speed

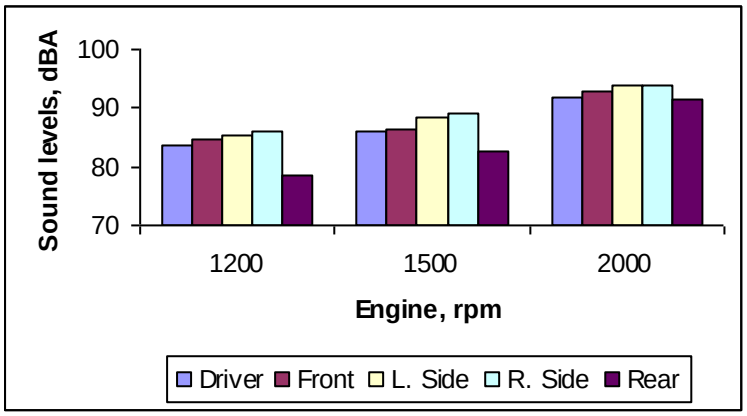
Effect of engine speeds on sound level in decibels (dBA) at the different position around the tractor (Driver seat, Front, L-side, R-side, and Rear the tractor) for three tractor categories were measured on concrete surface while the tractor was in position rest. The results were plotted in Figures 1,2 and 3. The maximum sound level values were measured for the three tractors at both right and left side, followed by the front side of the tractor. The minimum sound level values were measured for the three tractors at the rear and at driver’s seat position. For Landini tractor, when engine speed increased from 1200 to 1500 and from 1500 to 2000 rpm, resulted in an average increase of 2.4 % and 4.5 % in sound level respectively. The corresponding values for Nasr and Daedoge tractors were

3.3, 7.2% and 15,19% respectively. These results depended mainly on engine speed, rpm, which led to an increase in fuel consumption. The rotating parts of the tractor engine increased friction forces, which indicating more noise.

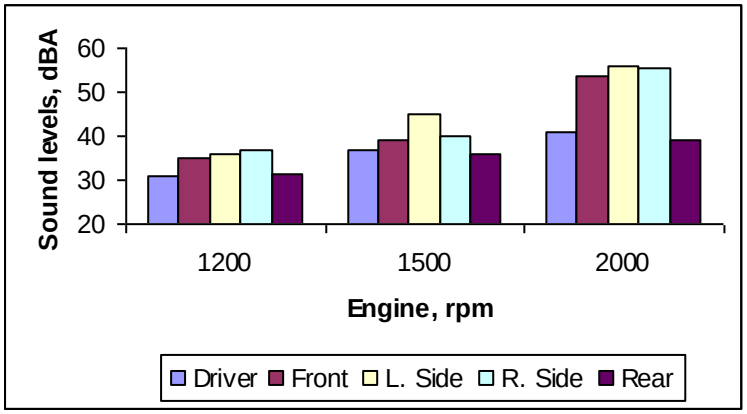
At 2000 rpm for Landini tractors the recorded values of sound levels ranged from 83 – 92 dBA. The corresponding values for Nasr tractor, which is the most popular tractor in Egyptian farms, ranged from 92 to 94 dBA. It should be mentioned that these values are due to tractors operation only at different positions, which mean that the sound will increase during agricultural machinery operation.



(Fig. 1): The effect of engine speed on sound levels recorded (Landini tractor).



(Fig. 2): The effect of engine speed on sound levels recorded (Nasr tractor).



(Fig. 3): The effect of engine speed on sound levels recorded (Daedong tractor).

Effect of Surface (ground types)

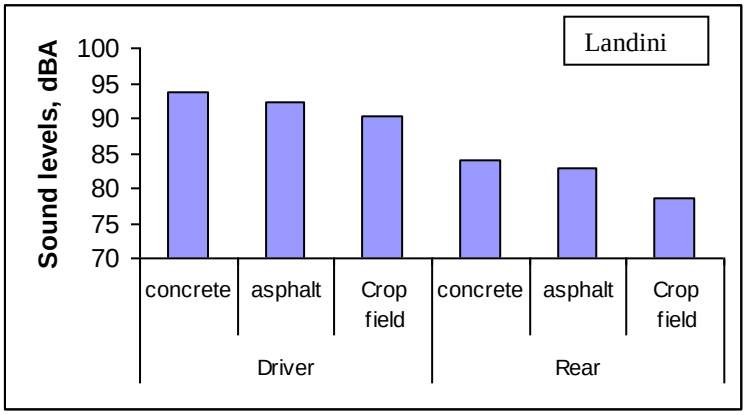
Effect of ground types on sound level (dBA) at the most effective position for driver and machine operator safety (Driver seat and rear of the tractor at I, II and III selected gears for "three tractor's speeds") were evaluated. The results were plotted in Figures 4,5 and 6.

It was noticed that the sound level at driver seat decreased by 1.34 and 2.98% when ground surface was changed from concrete to asphalt and from asphalt to crop field respectively. On the other hand the corresponding values at the rear of the tractor decreased by1.2 3 and 4.22 % compared to asphalt and crop field respectively for Landini tractor.

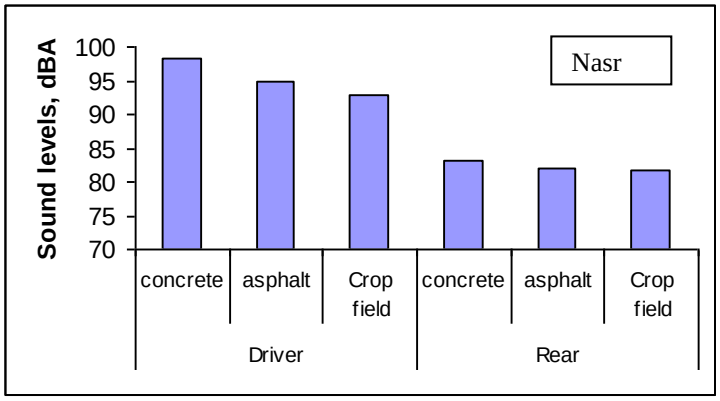
The sound level at driver seat decreased by 1.46 and 2.75% compared to asphalt and crop field, respectively. On the other hand the corresponding sound level values at the rear of the tractor decreased by 1.14 and 1.7 % for Nasr tractor.

The sound level at driver seat decreased by 2.2 and 4.65% compared to asphalt and crop field respectively. On the other hand the corresponding values at rear of the tractor decreased by 5.1 and 7.4 % compared with asphalt and crop field respectively for Daedong tractor.

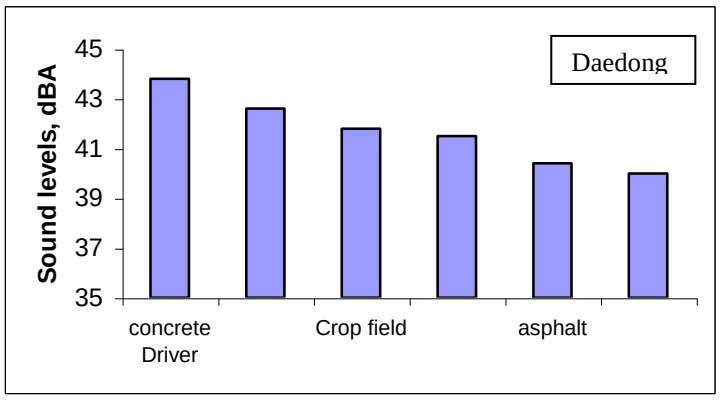
The maximum sound levels values 93.7, 92.2 and 90.2 dBA was recorded at driver seat on concrete, asphalt and crop surface at 2000 rpm for Landini tractor. The corresponding values for Nasr tractor the maximum values were 98.4, 95 and 93 dBA. According to Occupational Safety and Health (OSAH) there is greet danger for the tractor drivers working in this kind of environment. The working time should not exceed 3-4 hours if the sound level ranged between 95-97 dBA. The possibility of using hearing protection aid to increase the possibility of exposed time for tractor use without affecting the driver's ear. Also the use of tractor with cabin is highly recommended.



(Fig. 4): The effect of ground surface on sound levels recorded (Landini tractor).



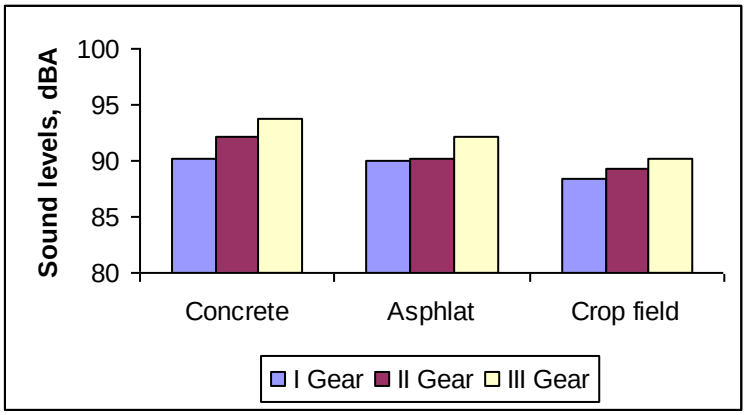
(Fig. 5): The effect of ground surface on sound levels recorded (Nasr tractor).



(Fig. 6):The effect of ground surface on sound levels recorded (Daedong tractor).

Effect of gear selection

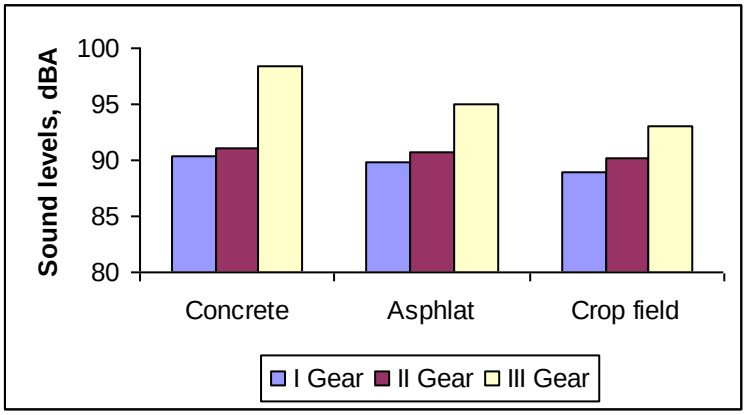
The effect of gear selection on sound recorded were measured at engine speeds of 1200, 1500 and 2000 rpm. The tests were done on three different ground surfaces: concrete, asphalt and normal crop field. The effect of gear selection on sound recorded at engine speeds of 2000 rpm are plotted in Figures 7 and 8. The maximum sound level was recorded at concrete surface. The values of sound level at driver seat using first and third gears ranged from 90.1 to 93.7 and 90 to 92.2 and 88.4 to 90.2 dBA for concrete, asphalt and crop field respectively for the Landini tractor at 2000 rpm. The corresponding values were 90.3 to 98.4 and 89.9 to 95 and 88.9 to 93 for concrete, asphalt and crop field respectively for Nasr tractor at the same engine speed. Meanwhile the sound levels recorded for Doedong tractor were 38.5 to 43.8 and 37.1 to 42.6 and 36.2 to 41.8 dBA for concrete, asphalt and crop field respectively at the same engine speed. The operation of this tractor was safe in term of sound levels, due to the decrease of engine weight and horsepower.



(Fig 7): The effect of gear selection on sound levels recorded on different ground surfaces for Landini tractor.

Most agricultural operations usually use the maximum engine speed, which ranges between 1500-2000 rpm. The recorded values of sound levels using third gear ranged from 87.1 to 95 and 87 to 93 for asphalt and crop field at engine speed of 1500 and 2000 rpm respectively for Nasr tractor. The corresponding values for Landini tractor were 92.2 to 93.7 and 88.6 to 90.2 respectively.

In general, according to Occupational Safety and Health (OSAH) 1980 there is great danger for the tractor drivers working in this kind of environment since the working time should not exceed 3-4 hours if the sound level ranged between 95-97 dBA. The possibility of using hearing aid to increase the tractor used time without affecting the driver ear may be considered as a solution to increase working times. Also the use of tractor equipped with cabin is highly recommended.



(Fig. 8): The effect of gear selection on sound levels recorded on different ground surfaces for Nasr tractor.

Conclusion and Recommendations

- The general recommendation of safety and occupational health dealing with protection from noise effects should be carefully followed, especially those (providing the tractor with a driver cabin, use of ear protection aids…etc) to help in reducting harmful effects of the exceeded sound levels.
- The obtained data during the present study should be considered while designing and /or positioning the hitched implements with the tractors.
- Further studies are necessary to modify the source parts causing noise vibration as well to reduce the possibility of noise hazards.
- The sound level should not exceed 85 dBA.

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مستويات الضوضاء الناجمة عن تشغيل الجرارات الزراعية

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معهد بحوث الهندسة الزراعية – الدقى - جيزة

يهدف هذا البحث إلى تحديد مستويات الضوضاء الناجمة عن ثلاثة من الجرارات الشائعة الاستخدام في ظروف التشغيل بالمزارع المصرية و ذلك فى محاولة لعمل قاعدة بيانات لاستخدامها في وضع الحلول الممكنه لتخفيض مستويات الضوضاء بالنسبة لمشغل كل من الجرار والمعدة الزراعية الملحقة. وقد تم دراسة كل من قدره الجرارات (٦٥,٦و ٤٨,٥و ٢٦ كيلو وات) باستخدامها فى ثلاث أنواع من الأراضي المختلفة وهى (الإسفلتية ،الخرسانية، ،التربة الزراعية)، وثلاث سرعات لمحركات الجرارات (١٢٠٠، ١٥٠٠، ٢٠٠٠ لفة/د) ، وثلاث اوضاع مختلفة للتروس في مواقع مختلفة للجرار (مقعد السائق، امام، جانب ايسر، جانب ايمن وخلف الجرار).

أشارات النتائج المتحصل عليها بأن أعلى قيمة للضوضاء قد سجلت للجرار النصر وبلغت قيمها ٩٨,٤، ٩٣,٧، ٩٤، ٩٤، ٩٢ ديسيبل عند مقعد السائق، امام الجرار، شمال الجرار، يمين الجرار، خلف الجرار على الترتيب. فى حين وصلت الى ٩٣,٧، ٩٠,٢، ٩٠,٨، ٩١,٥، ٨٣ ديسيبل للجرار لاندينى. اما بالنسبة الى الجرار ديدونج فكانت قيمها ٤١,٥، ٥٣,٨، ٥٥,٩، ٥٥,٦، ٣٩ ديسيبل فى نفس الاماكن على الترتيب.

أظهرت النتائج أن تغير السرعة من الترس الاول الى الثانى ومن الثانى الى الثالث أدى إلى زيادة مستوى الضوضاء المسجلة إلى ٢,٩، ٦% على التوالى.

كما أظهرت النتائج أن زيادة سرعة المحرك تزيد من الضوضاء في جميع المواقع حول الجرار وخصوصا عند سرعة محرك ٢٠٠٠لفة/د حيث إزادات الضوضاء وبمقارنة هذه الأرقام بالمستويات الموصى بها (OSHA) وجد أن العامل لا يستطيع العمل أكثر من ٣ ساعات يوميا بدون إستخدام وسائل الأمان وإلا فهناك إمكانية أن يصاب العامل بأضرار قد تفقدة السمع إذا استمر في العمل في هذا الجو بدون إستخدام وسائل الحماية.

يوصى البحث بضرورة إستعمال وسائل الآمان عند العمل بالجرارات بدون كابينة في العمليات الزراعية التي تحتاج سر عات عالية من المحرك، كما يوصى البحث بضرورة وجود كابينة في الجرارات لتوفير بيئة عمل آمنة لمستخدمي الجرارات الزراعية، كما حدد أفضل المواضع التي يمكن أن تلحق بها الآلة بالجرار لتخفيض مستوى الضوضاء بالنسبة للعامل المتابع لتشغيلها, كما يوصي البحث بإجراء المزيد من الأبحاث في مجال توفير بيئة عمل آمنة لمستخدمي الجرارات والآلات الزراعية.