Nature Environment and Pollution Technology
An International Quarterly Scientific Journal

ISSN: 0972-6268	Vol. 14	No. 3	pp. 485-492	2015

Original Research Paper

Assessment of Duration of Exposure to Noise by the Operators in Power Tiller Workplace

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Nat. Env. & Poll. Tech.
Website: www.neptjournal.com
Received: 7-11-2014
Accepted: 19-1-2015

Key Words:
Noise propagation
Power tiller
Noise contours
Agricultural workers

ABSTRACT

Every day, millions of agricultural workers are exposed to noise at work and all the risks this can entail. The World Health Organization (WHO) states "noise-induced hearing loss is insidious, permanent and irreparable". By using power tiller, more than the permissible exposure limit to noise may cause serious health problems to the agricultural workers. This paper examines the noise propagation of popular and most commonly used power tillers having a power rating of 11kW, 9.5kW and 4.4 kW. It was observed that all three power tillers produced the noise above 93 dB(A) in the working zone of the operator. The density of noise contour and SPL is proportional to the engine rpm or load. The working radius around PT-I, PT-II and PT-III of 3.5 m, 2 m and 5.6 m was found noisy [>90 dB(A)] and not suitable to work 8 h per day as per recommendation of ISO and OSHA. The permissible duration of exposure to noise for operator for PT-I, PT-II and PT-III varies from 7.8 h to 3.6 h, 13 h to 5.1 h and 5.3h to 2.1h, respectively for different engine rpm.

INTRODUCTION

Protection and improvement of workers' safety and health plays an important role in the process of farm mechanization. Farm mechanization introduced new risks to the sector, mainly associated both with the use of more sophisticated agricultural machinery without adequate safety measures, information and training, as well as the intensive and indiscriminate use of chemicals in agriculture. The outcome has been not only an increase in the number of serious injuries and death, but also the destabilization of the ecosystems of large areas of the world due to a non-sustainable approach to the agricultural development.

In farm works, the fatigue and discomfort to which human beings are subjected is not only due to physical labour, but to vibration and noise as well. More hearing loss is encountered among people who work in agricultural fields than other jobs (Baker 2002). Exposure to noise may create musculoskeletal disorders (repetitive motion disorders and back disorders), stress and psychological disorders. This situation is particularly evident in developing countries where education, training and safety systems are largely inadequate to provide coverage to the sector (Forastieri 2000). Noise can cause hearing impairment, interfere with communication, disturb sleep, cause cardiovascular and psycho-physiological effects, reduce performance, and provoke annoyance response and changes in social behaviour (WHO 2001). Pessina & Guerretti (2000) found that the average noise level at the tractor driver's ear was about 87-88 dBA, with a maximum of 101 dBA. At full power, the motor produces far more than the 85 dB(A) established as the limit for hearing loss prevention (Darabont 1983). The level of annoyance depends not only on the level of the noise, but also operator's position and the duration (Celen & Arin 2003). In Poland farmers were found to be exposed to a mean annual level of noise exposure of LEX, 8h = 89.1 dB (Solecki 2003). An investigation conducted by Dewangan et al. (2005), found that the sound level of the tractors and power tillers under the study was more than the permissible limit of sound level for 8 hour duration/day as recommended by OSHA and hence require suitable measures to protect the operator and workers around these machines against excessive sound.

The noise produced by power tillers may cause discomfort, nervousness, tension, irritability and fatigue. Levels from 86 to 115 dB (A) can cause specific effects to the ear such as the damage of the corticells and can involve psychosomatic diseases. Noise also results in increase in the pulse rate and blood pressure and irregularities in heart rhythm. Occupational Safety and Health Administration, USA has given a standard OSHA-1910.95 for occupational noise exposure. It mentions that the permissible daily (8-h) exposure to the operator is to be up to 90 dB (Table 1). The

Table 1: Permissible daily noise exposure as per OSHA 1910.95.

Duration per day, hours	Sound level dB(A)	Duration per day, hours	Sound level, dB(A)
8	90	1.50	102
6	92	1.00	105
4	95	0.50	110
3	97	0.25	115
2	100	-	> 115

other remedial measures against noise as health hazard may be noise reduction at source or at emission or use of personal protection such as ear plugs.

In past, extensive research work has been done in the western countries for measurement of noise produced in agricultural operations (Peng & Lines 1995, Ragni et al. 1999, Parsons 2000). The topic of noise and its effects in agriculture has received much attention since 1960s (Matthews 1968). However, the literature available on safe noise exposure duration with power tillers in Indian condition is limited. Moreover, no study has been conducted in India to determine safe exposure limit with different power rating hand tractors for different engine rpm. So, a study was conducted at Indira Gandhi Krishi Viswavidyalaya, Raipur to analyse the noise level of popularly used power tillers in India and to optimize the safe exposure limit for operator to operate power tillers without causing any health problem.

MATERIALS AND METHODS

Experimental Conditions

The experiments were conducted in the open field to study the noise propagation in a stationary condition of power tillers. There were no obstructions like trees, buildings, solid fences, rocks and other objects in the radius of 100m. The surface area of the experimental site was free from acoustically absorptive materials like tall grasses, standing crops etc. The experiments were conducted during the morning

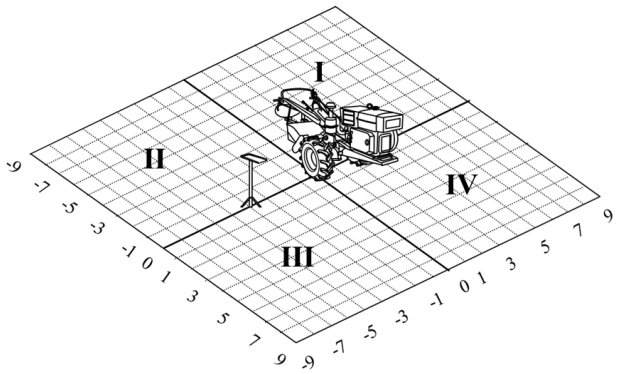

Fig. 1: Field layout along with the power tiller.

Table 2: Brief specification of power tillers.

Power Tiller	Rated Power, kW	Rated Engine Speed, rpm	Gears
PT-I	11.0	2000	6 forward, 2 reverse
PT-II	9.5	2300	6 forward, 2 reverse
PT-III	4.4	1500	No gears

(5.00 am to 9.00 am) and evening (4.00 pm to 7.00 pm) hours so as to minimize the errors due to background noise. The ranges of average mean dry bulb temperature, relative humidity and wind velocity during the experiment were 21.2 ± 2.1°C, 71.4 ± 3.2% and 1.1 ± 0.26 m/s respectively. The texture of the soil at experimental plot was 61.9% sand, 11.6% silt and 25.4% clay and the type of soil was lateritic with sandy loam. The average moisture content and bulk density before operation were 16.42% (dry basis) and 1.66 g/cm^3 respectively. The experimental conditions are suitable to conduct noise measurement experiment according to the test code IS-12180:2000, ISO-7216:1992.

Three most popular and commonly used models of power tillers were selected for the study. Their brief specifications are given in Table 2. The tyres fitted to these machines were of standard size and the depth of tread was not less than 65% of the depth of new tread. The recommended tyre inflation pressure was maintained.

Experimental Procedure

To measure the sound propagation characteristics in terms of sound pressure level (SPL), grid points were marked in the field using cross staff, ranging rod and measuring tape at a grid spacing of 1.0 m × 1.0 m. The centre of the right wheel of power tiller was considered as (0, 0) coordinate. The noise was measured in accordance with the guidelines given in ISO-1999 standard. Digital sound level meter of SL 4001 (Lutron) was used having 3½ inch digit LCD display, 18 mm size, function dB (A and C weight) fast, slow and maximum hold response. The sound level readings were recorded in digital sound level meter by holding it at a height of 1.0 m from the ground level for 30 seconds at each grid points. The readings were taken at each grid point up to a distance, where the sound level attenuated to below 75 dBA. The equivalent sound level (L) recorded by the sound level meter at each grid point was used to draw the contour of sound level at an interval of 2 dBA. Three replications were conducted for obtaining each reading.

RESULTS AND DISCUSSION

Noise Propagation

Sound Pressure Level (SPL) was measured at four different

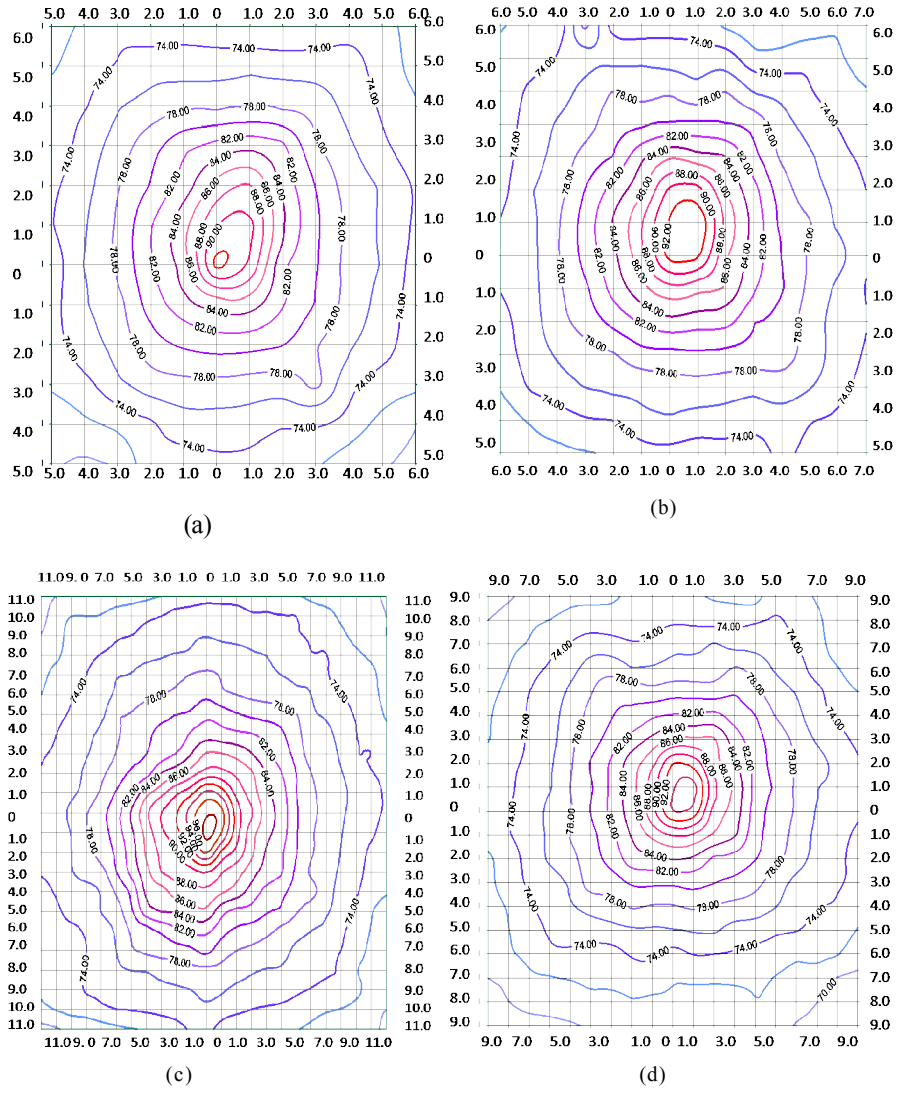

Fig. 1: Noise contour of power tiller-I: (a) 1/4th of engine rpm; (b) ½ of engine speed; (c) 1/3rd of engine rpm; (d) full engine rpm.

levels of engine rpm viz., ¼, ½, ¾ and full. Noise contour maps were prepared from the observed values of SPL at different grid points of 1×1 m as shown in the Fig. 1. Data revealed that, the SPL of all the power tillers was found to be increasing with the increase in engine speed. Rate of noise attenuation was found slower in the quadrant I, i.e. on exhaust side of power tiller and which was faster in the other three quadrants. This may be due to the position of exhaust as it is the main source of sound. The same results were found by Kathirvel (1994).

At grid points 0,0; 0,1; 1,0 and 1,1 SPL was more than 90 dB (A) which indicate that the 8 h duration per day work was not allowed to the operator (Fig. 1a). Similarly from the Fig. 1b, the SPL was found to be more than 90 dB (A) at grid points 0,0; 0,1; 0,2; 1,0; 2,0; 2,1; 1,1 and 2,2 in the quadrant I. Similar trend of noise attenuation was found on ¾ (Fig. 1 c) and full (Fig. 1d) engine rpm, but the area of 90 dB(A) contour was increased, that means the ears of person working at distance of 3.5 m away from power tiller will have noise exposure more than 90 dB (A).

At full engine rpm, 90 dB (A) contour line covers area up to 2 m distance surrounding the PT-II. The SPL at operator's ear level was increased by 6.88 percent with the increase in rpm from ¼ to full. This means that operator is not outside the zone of permissible noise exposure for 8 hr duration per day.

Contour line of 90 dB(A) covered the distance of 1.3, 2.6, 3.7 and 5.6 m surrounding the PT-III at ¼, ½, ¾ and full

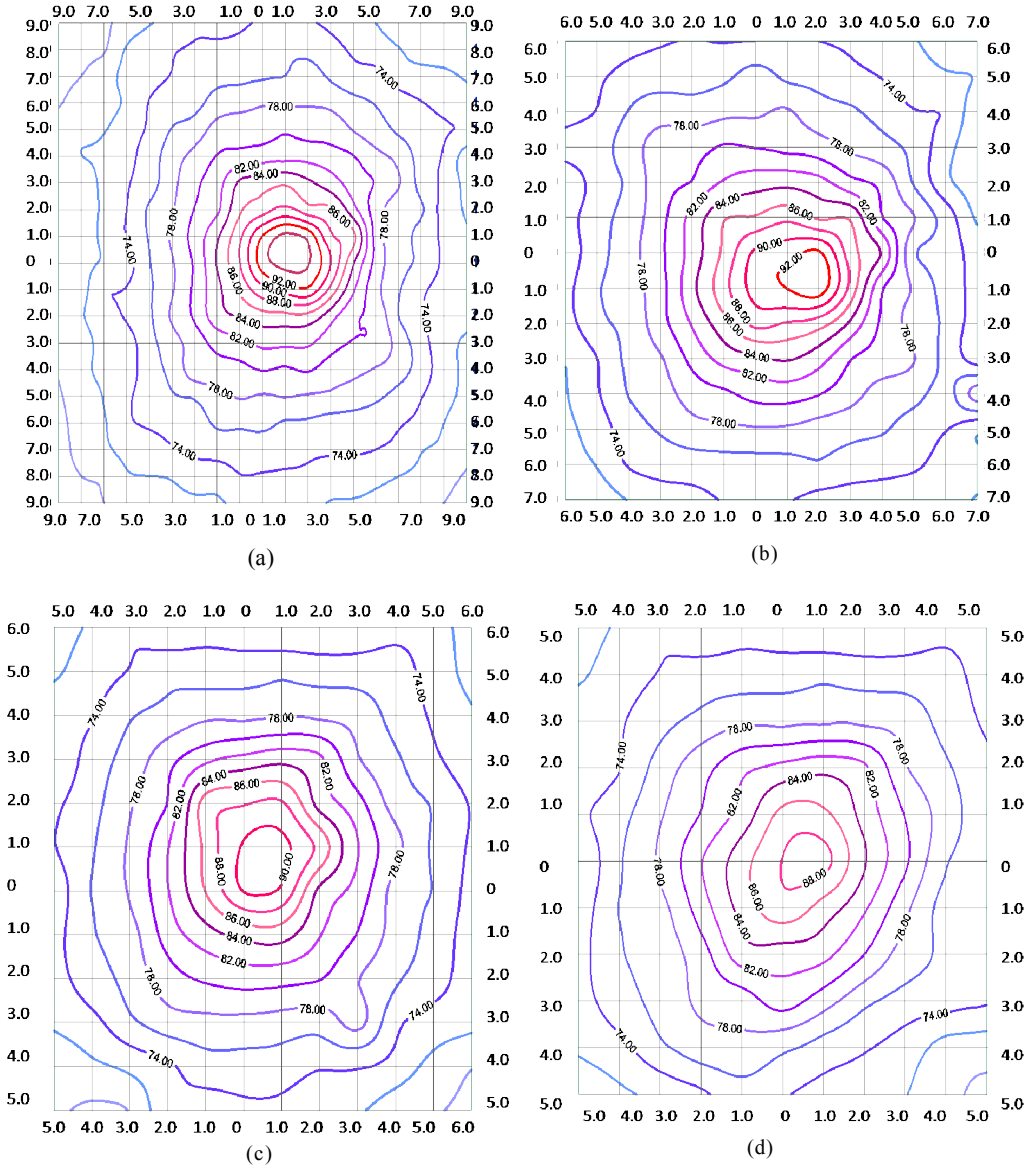

Fig. 2: Noise contour of power tiller-II: (a) 1/4th of engine rpm; (b) ½ of engine speed ;(c) 1/3rd of engine rpm; (d) full engine rpm.

engine rpm respectively (Fig. 3). This means that the workers other than power tiller operator working around the power tiller up to a distance of 5.6 m will be affected by the noise produced at a particular engine rpm.

Relationship Between SPL and Engine RPM

For PT-I, with the increase in engine rpm, equivalent sound pressure level increases linearly from 93.1 to 98.8 dB(A) and 90.3 to 96.1 dB(A) at exhaust and at operator's ear level respectively (Fig. 4). PT-II (Fig. 5) shows the linear trend in SPL at exhaust and operator's ear level. SPL was increased linearly from 89.3 to 95.4 dB(A) at exhaust whereas at operator' ear level it was increased from 87.4 to 93.4 dB(A) linearly with the increase in engine rpm from ¼ to full. PT-III shows the same trend as that of PT-I and II. SPL at exhaust was found highest for PT-III, which increased from 92.7 to 100.3 dB(A) (Fig. 6). Alike at the exhaust, SPL was increased linearly from 91.8 to 99.7 dB (A). The outcome of the investigation coincided with the results obtained by other researchers, viz., Dewangan et al. (2005) and Shrivastva et al. (2004).

Permissible Duration of Exposure to Noise

According to ISO standard curves for allowable exposure time

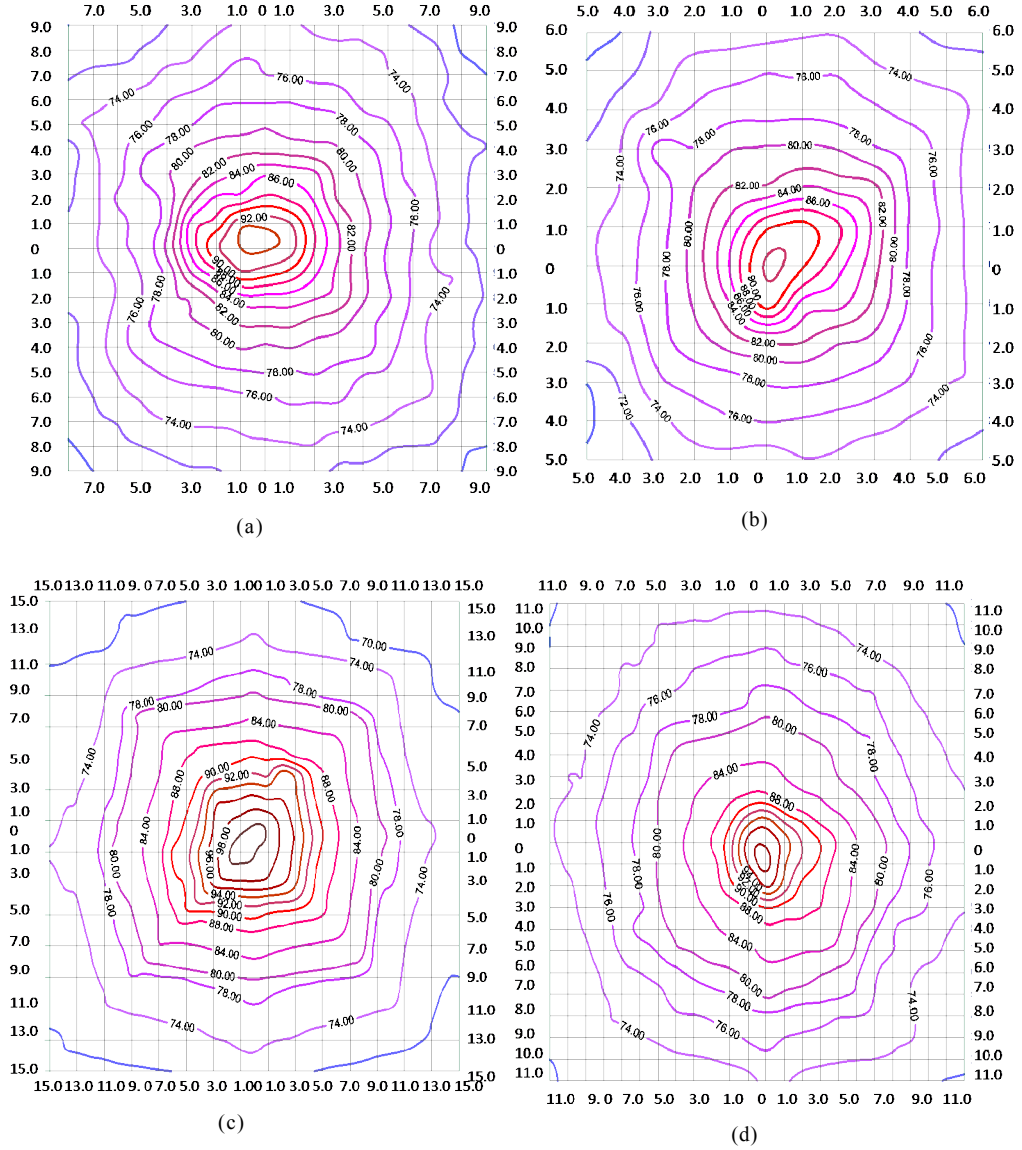

Fig. 3: Noise contour of Power tiller-III: (a) 1/4th of engine rpm; (b) ½ of engine speed; (c) 1/3rd of engine rpm; (d) full engine rpm.

of operator for various sound levels, the permissible exposure time of the operator for PT-I varies from 7.8 h to 3.6 h (Fig. 7), for PT-II 13 h to 5.1 h (Fig. 8) and for PT-III 5.3h to 2.1h (Fig. 9). This clearly specifies the stipulation of suitable control measures to reduce the operator's exposure to noise.

CONCLUSIONS

The following conclusions have been drawn from the investigation:

i. The SPL increases with the increase in engine rpm. Density of noise contour is proportional to the engine rpm or load.

ii. The SPL of the power tillers under the study was more than the permissible limit of sound level for 8-hour duration/day as recommended by ISO, and hence requires suitable measures to protect the operator and workers around these power tillers against excessive sound.

iii. The working radius around power tiller of 3.5 m, 2 m and 5.6 m was found noisy [>90 dB(A)] and not suitable to work 8 h per day as per recommendation of ISO and OSHA.

iv. The permissible duration of exposure time of the operator for PT-I varies from 7.8 h to 3.6 h, for PT-II 13 h to 5.1 h and for PT-III 5.3h to 2.1h for different engine rpm.

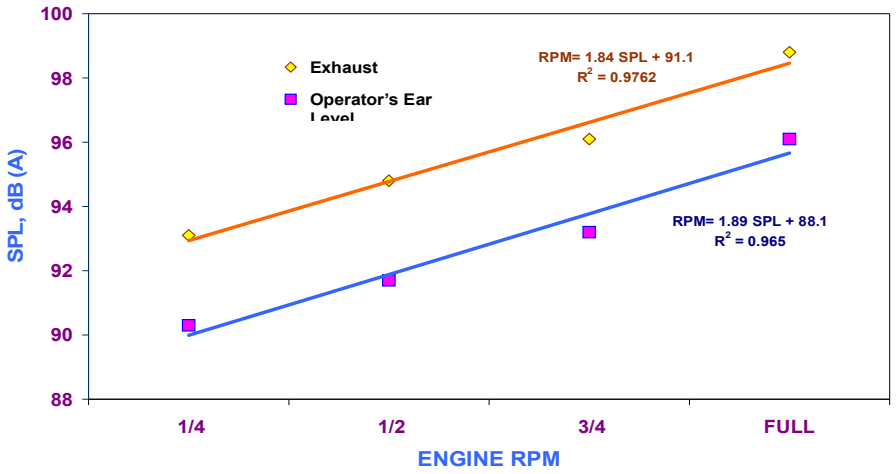

Fig. 4: Relation between SPL and engine speed of power tiller-I.

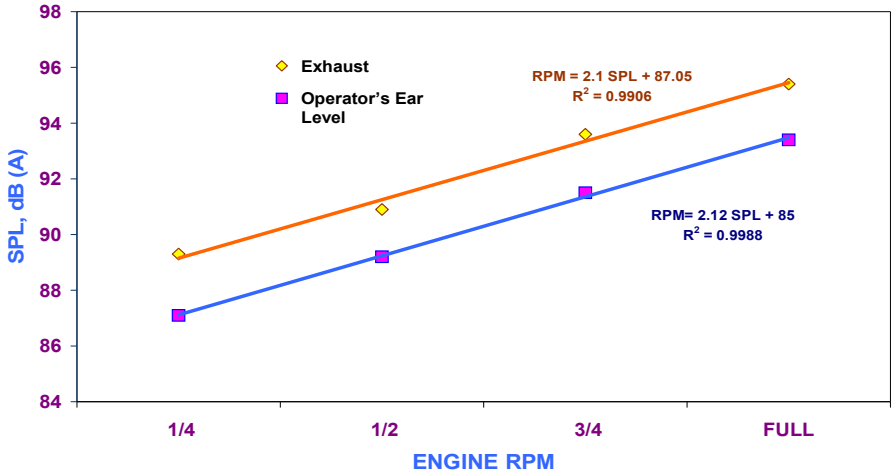

Fig. 5: Relation between SPL and engine speed of power tiller-II.

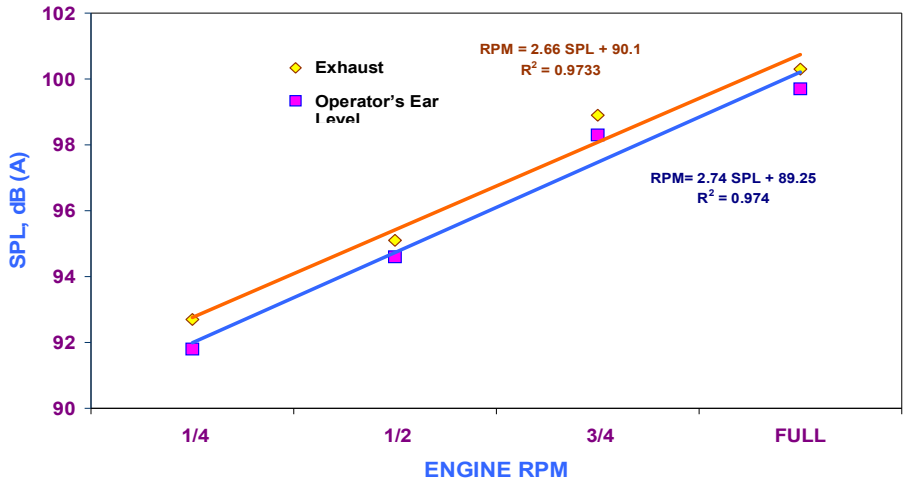

Fig. 6: Relation between SPL and engine speed of power tiller-III.

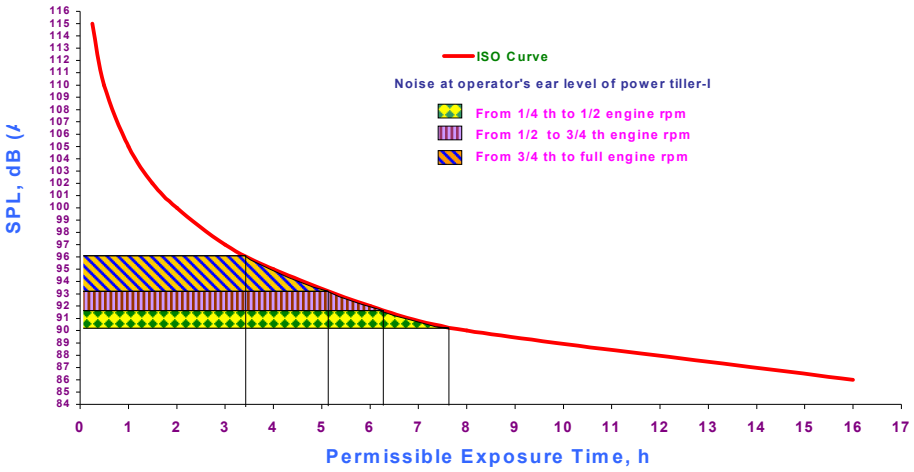

Fig. 7: Relation between noise and exposure time of power tiller-I.

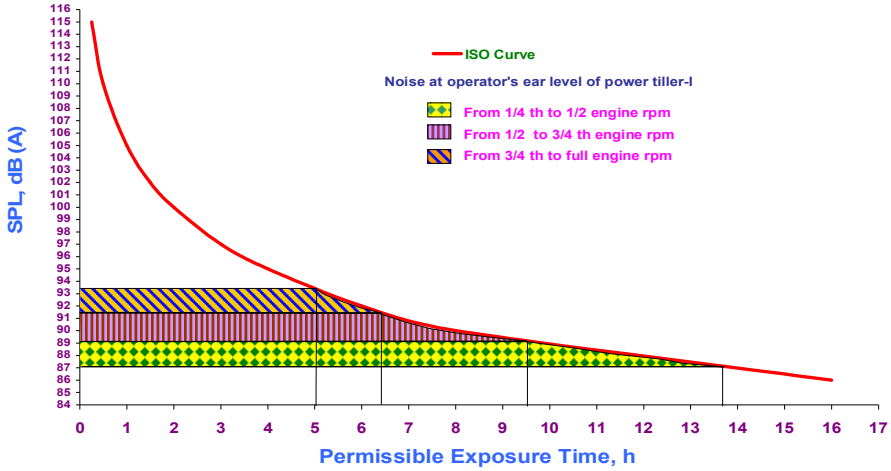

Fig. 8: Relation between noise and exposure time of power tiller-II.

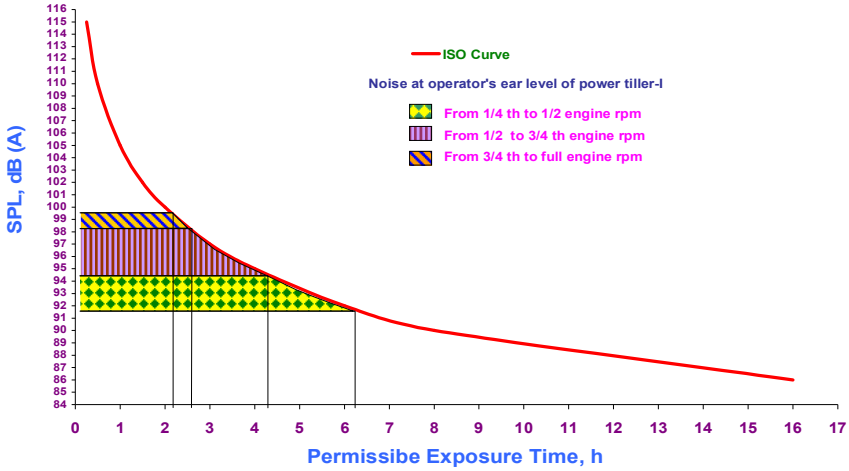

Fig. 9: Relation between noise and exposure time of power tiller-III.

Based on the results and discussion in this study, the following recommendations could be made:

i. Adequate information, training and manual of safety to noise should be provided to instruct the operator to use power tiller in a manner to reduce their exposure to noise to a minimum.

ii. Limiting the duration and intensity of the exposure and/or by organizing appropriate work schedules with adequate rest periods.

ACKNOWLEDGEMENT

The authors are grateful to ICAR New Delhi, Niche Area of Excellence Programme-Farm Mechanization in Rainfed Agriculture, for granting financial assistant during the course of the investigation.

REFERENCES

Baker, D.E., 2002. Noise: The invisible hazard. Department of Agricultural Engineering, University of Missouri, Columbia.

Celen, I.H. and Arin, S. 2003. Noise levels of agricultural tractors. Pakistan J. of Biological Sciences, 6(19): 1706-1711.

Darabont, A. 1983. Noise, measurement and control. In: Encyclopaedia of Occupational Health and Safety. Parmeggiani, L. (ed.), 3rd (revised) edition, ILO.

Dewangan, K.N., Prasannakumar, G.V. and Tewari V.K. 2005. Noise characteristics of tractors and health effect on farmers. Applied Acoustics, 66: 1049-1062.

IS-12180:2000, ISO-7216:1992. Tractors and machinery for agriculture and forestry-noise measurement-method of test.

ISO-1999. Acoustics, assessment of occupational noise exposure for bearing conservation purposes. International Organization for Standardization, Geneva.

Kathirvel K., Binisam, Manian R. and Senthilkumar T. 2004. Effect of noise on safe exposure limit of power tiller operator. Agricultural Engineering College and Research Institute, TNAU, Coimbatore, Paper presented in XXXVIII Annual Convention of Indian Society of Agril. Engineers held at Dapoli, 16-18.

Keszek Solecki 2003. Preliminary evaluation of occupational hearing loss risk among private farmers. Ann. Agric. Environ. Med., 10: 211-215.

Matthews, J. 1968. Measurement of environmental noise in agriculture. Journal of Agricultural Engineering Research, 13(2): 157-167.

OSHA-1910.95 1981. Occupational noise exposure. Occupational Safety and Health Standards.

Parsons K.C. 2000. Environmental ergonomics: A review of principles, methods and models. Appl. Ergon., 31:581-94.

Peng, C., Lines, J.A. 1995. Noise propagation in the agricultural environment. Agric. Engg. Res., 60: 155-65.

Pessina, D. and Guerretti, M. 2000. Effectiveness of hearing protection devices in the hazard reduction of noise from used tractors. J. of Agric. Engg., 75(1): 73-80.

Ragni, L., Vassolini, G., Xu, F. and Zhang, L.B. 1999. Vibration and noise of small implements for soil tillage. J. of Agric. Engg. Res., 74: 403-409.

Shrivastava, A.K., Arora, A., Shrivastava, A.K. and Mehta, C.R. 2004. Study of noise levels of a 3.7 kW diesel engine. Paper presented in XXXVIII annual convention of Indian Society of Agric. Engineers held at Dapoli, 16-18.

Singh, G. 2002. Equipment to ensure timeliness. The Hindu Survey of Indian Agriculture. 195-198.

Valentina, Forastieri 2000. The ILO Programme on Safety and Health in Agriculture: The challenge for the new century - providing occupational safety and health services to workers in agriculture. Labour Education.

WHO 2001. Factsheet 258, Occupational and community noise. World Health Organisztion.