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Evaluation of Tractor Noise Level during Tillage Operation with a Disc Plough

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Abstract:
Tractor noise spectra cover the entire audible range from 20 Hz to 20 kHz. It consists of engine noise, exhaust, intake fan and mechanical noise created by combustion, gears, cams, bearings and pumps, etc The severity associated with noisy tractor may be annoying to varying degrees, lack of concentration, fatigue, rhythm disturbance and damage to hearing. In this paper noise level of tractor (MF 1035 ID) at the operator's ear level and for bystander position was measured during no load (NL) and tillage operation with a disc plough at different tillage depths and different engine speeds. The results showed that noise level during tillage operation higher than during NL condition. It is found that the effect of tillage depth, engine speed and the interaction between them on the level of tractor noise was significant at the 5 percent level of significance. It is observed that noise at a tractor operator's ear level during tillage operation with a 2 bottoms disc plough was higher than the permissible level (85 dB (A)) which was given by Occupational Safety and Health Administration

(OSHA) and National Institute for Occupational Safety and Health (NIOSH).

Key words: Noise; Tractor Noise; Agricultural workers; Tractor operator's health; noise measurements

Introduction

Tractor is an agricultural machine which is fitted with a diesel engine. It is one of the most important farm machineries. It is really a multipurpose machine used widely in agriculture. It is believed that true revolution in the field of agriculture was brought out with the help of tractors. Farmers used to pulverize and grow crops through their bare hands. Tractors have become the main source of power in Indian farm. The tractor production increased steadily from I96I -1962, when the production was mere 880 tractors per year to 1999-2000, when it has reached the record of 2.67 lakhs, the highest in the world **(Anon., 2014). Ghuge 2008** reported that the tractor utilization was 677.47 hours, annually for different agricultural operations and 140.70 for non-agricultural work. Noise is an unwanted sound which is a vibrational phenomenon transmitted through solid, liquid or gas medium. This interpretation implies s value judgment of the sound, which in turn generally implies the response of human beings to the environment. It is one of the most important environmental factors, which affects the workers' health and efficiency. Exposure to continuous noise of 85-90 dB(A), particularly over a lifetime in industrial settings, can lead to a progressive loss of hearing, with an increase in the threshold of hearing sensitivity **(Stansfeld S.A. and M.P. Matheson (2003)).** Since all the tractors, manufactured in India are operated by diesel engines, they are very much affected by their high intensity of vibration and higher sound level. This has led to a serious increase during the last few decades of the exposure of farm worker to vibration and noise. Recently noise generated by tractors has received a great deal of attention, not only from the operator but from the manufacturer as well. The increased emphasis on operator's safety and comfort has created a demand for stricter control of these aspects. The severity related to noisy tractor may be annoying to varying degrees, lack of concentration, fatigue, rhythm disturbance and damage to hearing. Approximate rules have been laid down, which specify the safe noise level for no permanent hearing loss, usually for an exposure of 8 h per day for a working lifetime **(Aybek et al. (2010)).** If tractors produce noise more than 85 dB(A) for 8 hours exposure (based on the **(NIOSH, 1998**) noise exposure recommendation) it will harmful both drivers and bystanders. Noise can increase the overall workload of operators during a specific task and can affect the performance. As a result, noise affects workers' health directly and indirectly **(Jaliliantabar *et.al.* (2013)).** Keeping all these points in mind, field experiments were performed to assess the noise level of the tractor while used in tillage operation with disc plough.

Materials and Methods

Evaluation of noise level for at Tractors Operator's Ear Level and Bystander Position

A field experiment was carried out at the SHIATS farm, Allahabad; UP during November 2014 to evaluate the effect of engine speed and tillage depth on the level of noise of the tractor at tractor operators' ear level and bystander position during tillage with disc plough according to the SAE noise measurement procedure. Six years old Massey-Ferguson (MF 1035 DI) tractor attached with 2 bottoms disc plough was used in this study. A precision sound level meter with a condenser microphone type 4165 was used with a frequency range of 20 Hz to 20 KHz.

Area for Noise Level Measurement

The tractor was situated on the straight test path having a length of 20 m. The speed of the tractor should be stabilized for an adequate time. The noise meter was mounted 1.5 m above the ground surface and 100 mm away from the operator right ear. Fig.1 shows the dimensions of the area in which the tractor noise was measured. The minimum values of R, L and W will be at least 20, 15 and 2 m respectively.

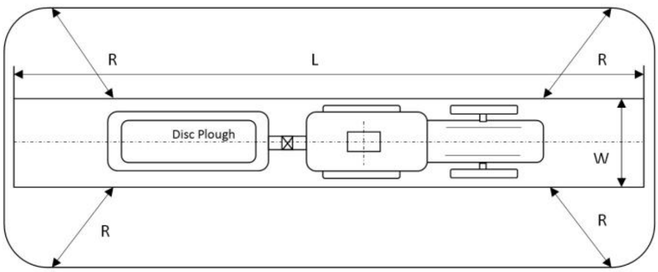

Figure 1: Noise Measurement Area for Operator's Ear Level

Area of Noise Measurement for Bystander's Position

The test specifications will be similar to the specification mentioned for the operator's ear level except that the noise meter will be mounted 7.5 m away from the center line of tractor path and 1.2 m above the ground surface. Fig.2 shows the dimensions of the area in which the tractor noise will be measured. The minimum values of R, L and W will be at least 20, 15 and 2 m respectively. Table 3.3 shows the detail of experimental design during tillage operation with a disc plough.

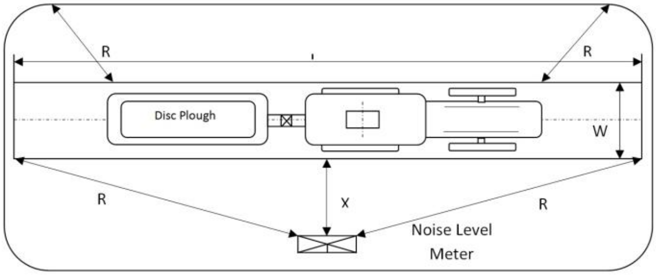

Figure 2: Noise Measurement Area for Bystander's Position

Table 1: Details of Design of the Experiment for Evaluation of Tractor Noise Level during Tillage with Disc Plough

Dependent variables	Independent variable	Levels	Description
Noise Level dB(A)	Tillage Depth	4	No Load (NL), 10, 14 and 18 cm
	Engine Speed	3	1000, 1500 and 2000 rpm

Replications 6
Trials 6 x 3x4 = 72
Design Factorial Randomized Block Design (FRBD)

Experiment Procedure

1- Driver asked to operate the tractor in the field at no load (NL) (without tillage) at G1 high forward and engine speed was maintained at 1000 rpm
2- Noise level at the drivers' ear level was measured using the noise level meter.
3- Noise level at bystander's ear level was recorded using the noise level meter.
4- Step 1 to 3 were repeated 6 times in order to get six replications
5- Step 1 to 4 were repeated for engine speed 1500 to 2000 rpm respectively.
6- Driver asked to operate the tractor in the field at G1 high forward. Tillage depth was maintained at 10 cm and engine speed was kept at 1000 rpm
7- Noise level at the drivers' ear level was measured using the noise level meter (Fig.3).
8- Noise level at bystander's ear level was recorded using the noise level meter (Fig. 4).
9- Step 6 to 8 were repeated 6 times in order to get six replications.
10- Step 6 to 9 were repeated for tillage depth 14 and 18 cm respectively.

The effect of tillage depth and engine speed on the noise level was evaluated statistically

Figure 3: Noise Level Measurement at Driver's Ear Level during disc Ploughing

Figure 4: Noise Level Measurement for Bystander during Disc Ploughing

Results and Discussion

The experiment was conducted while Massey-Ferguson (MF 1035 DI) tractor attached with 2 bottoms disc plough at no load (NL) in the field at different engine speed then during tillage operation at different tillage depths and different engine speeds. Fig.5 shows the mean noise level for operator's ear level produced by the tractor during no load (NL) and tillage operation at different tillage depths for different engine speed. The maximum of mean noise level during NL was 87.7 dB(A) at 2000 rpm engine speed. The minimum of mean noise level during NL was 82.58 dB(A) at 1000 rpm engine speed. Fig.5

indicates that during tillage operation at a constant engine speed, the mean noise level for operator's ear level increased as the tillage depth increased. Also it's clear that during tillage operation at constant tillage depth, the noise level for operator's ear level increased as engine speed increase. The minimum noise level for the operator's ear level was 84.9 dB(A) at 10 cm tillage depth and 1000 rpm engine speed. The maximum noise level at the operator's ear level was 97.72 dB(A) at 18 cm tillage depth and 2000 rpm engine speed. These noise levels were more than the recommended level of 85dB which indicate that the operators were under threat from noise and safety measures are desirable. The use of ear protector such as ear plugs and muff and tractor cabins are recommended as means by which the noise exposure could be reduced. The present study is in a broad agreement with study of **Eltawil1 and Hegazy (2011), Jaliliantabar et al. (2013), Lar *et al.* (2012) and Monazzam et al. (2012).**

The effect of tillage depth and engine speed on tractor noise level for the operator's ear level during tillage operation was evaluated statistically and presented in Table 2.

Table 2 shows the mean values of noise level produced by the tractor noise at the operator's ear level during tillage operation while using disc plough.. The effects of tillage depth, engine speed and the interaction between them were significant at 5percent level of significance. From this study it was observed that as depth of tillage increased from 10 to 14 cm and from 14 to 18 cm and engine speed remained constant the noise produced by the tractor at operator's ear level also increased. The minimum noise levels were observed during tillage operation at 10 cm depth followed by 14 and 18 cm tillage depth respectively. This was due to the fact that the load increased as a tillage depth increased and the engine had to produce more horsepower to overcome the load increment and this increased the noise. Also, it is observed from this study that during the tillage operation at a constant tillage depth and engine speed increased from 1000 to 1500 rpm and from 1500 to 2000 rpm, the noise produced by the tractor at operator's ear level also increased. This was due to the fact that the noise produced by tractor increased as engine speed increased. From Table 4.5 it is observed the noise at a tractor operator's ear level during tillage operation with disc plough was higher than the permissible level (85 dB (A)) which was given by Occupational Safety and Health Administration (OSHA) and national institute for occupational safety and health (NIOSH) and International Organization for Standardization (ISO) .

Fig.6 shows the mean noise level for bystander's position produced by the tractor at no load (NL) and during tillage operation at different tillage depths and different engine speed. The maximum of mean noise level during NL was 79.33 dB(A) depth and 2000 rpm engine speed. The minimum of mean noise level during NL was **6**5.73 dB(A) at 1000 rpm engine speed. Fig.6 indicates that during tillage operation at a constant engine speed, the mean noise level at bystander's position increased as the tillage depth increased. Also it is clear that during tillage operation at constant tillage depth, the noise level at bystander's position increased as engine speed increase. The minimum noise level at bystander's position was found 67.48 dB(A) at 10 cm tillage depth and 1000 rpm engine speed. The maximum noise level at bystander's position was 79.33 dB(A) at 18 cm tillage depth and 2000 rpm engine speed.

The effect of tillage depth and engine speed on the tractor noise level at bystander's position during tillage operation was evaluated statistically and presented in Table 3.

Table 3 shows the mean values of noise level produced by the tractor noise at bystander's position during tillage operation while using disc plough. The effects of tillage depth and engine speed on the tractor noise level at bystander's position during tillage operation were significant at 5 percent level of significance. However, the effect of the interaction between tillage depth and engine speed was not significant.

From this study it was observed that as depth of tillage increased from 10 to 14 cm and from 14 to 18 cm and engine speed remained constant the noise produced by the tractor at bystander's position also increased. The minimum noise level was observed during tillage operation at 10 cm depth followed by 14 and 18 cm tillage depth respectively. This was due to the fact that the load increased as a tillage depth increased and the engine had to produce more horsepower to overcome the load increment and this increased the noise. Also, it is observed from this study that during the tillage operation at a constant tillage depth and engine speed increased from 1000 to 1500 rpm and from 1500 to 2000 rpm, the noise produced by the tractor at bystander's position also increased. This was due to the fact that the noise produced by tractor increased as engine speed increased. From Table 3 it is observed the noise at a at bystander's position during tillage operation was lower than the allowable level (85 dB (A)) which was given by occupational safety and health administration (OSHA) and national institute for occupational safety and health (NIOSH). Fig.5 and Fig.6 show that the noise produced by the tractor at operator's ear level was higher than at the bystander's position.

Conclusions

It may be concluded that The noise produced by tractor at the operator's ear level during tillage with a disc plough is more than the allowable level of 85dB(A) except at 10 cm tillage depth and 1000 rpm engine speed the noise level slightly less. This indicates that the operator was under threat from noise and safety actions are desirable. The tractor drivers should always work with lowest engine speed and in this case, the tractor would not produce sufficient power to execute the job. The other solutions are either staying on driving for less than 2 hours with tractors without a cabin or an open window cabin or the use of the ear protector such as ear plugs and muff and tractor cabins are recommended as means by which the noise exposure could be reduced.

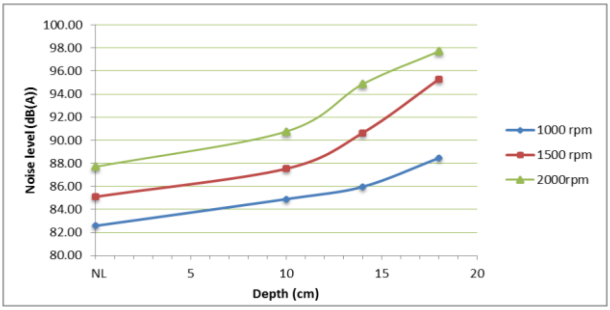

Figure 5: Effect of Engine Speed and Tillage Depth on Tractor Noise Level during Disc Ploughing at Operator's Ear Level

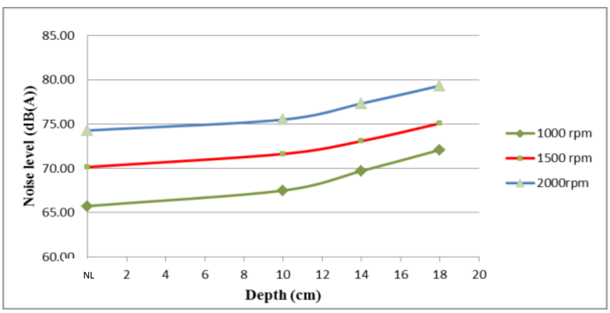

Figure 6: Effect of Engine Speed and Tillage Depth on Tractor Noise Level during Disc Ploughing for Bystander's Position

Table 2: Tractor Noise Level during Disc Ploughing at the Operators' Ear Level

Level of Engine Speed (ES)	**Noise Level**				**Mean Noise Level**
	Tillage Depth				
	No Load	**10 cm**	**14 cm**	**18 cm**	
1000 rpm	82.58	84.90	85.97	88.47	**85.48**
1500 rpm	85.10	87.53	90.63	95.30	**89.64**
2000rpm	87.70	90.77	94.87	97.72	**92.76**
Mean Noise Level	**85.13**	**87.73**	**90.49**	**93.83**	
Factors		**F-test**	**S. Em. (±)**	**C.D. at 5%**	
Depth (D)		S	0.193	0.385	
Engine Speed (ES)		S	0.222	0.445	
Interaction (D x ES)		S	0.385	0.771	

Table 3: Tractor Noise Level during Disc plowing for Bystander's Position

Level of Engine Speed (ES)	Noise Level				Mean Noise Level
	Tillage Depth				
	No Load	10 cm	14 cm	18 cm	
1000 rpm	65.73	67.48	69.67	72.08	**68.74**
1500 rpm	70.15	71.63	73.08	75.08	**72.49**
2000 rpm	74.28	75.52	78.33	79.33	**76.87**
Mean Noise Level	**70.06**	**71.54**	**73.69**	**75.50**	
Factors		**F-test**	**S. Em. (±)**	**C.D. at 5%**	
Depth (D)		S	0.647	1.294	
Engine Speed (ES)		S	0.747	1.494	
Interaction (D x ES)		NS	1.294	2.588	

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