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Noise Levels of Agricultural Tractors

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Abstract: In this study, a digital sound level meter was used to measure noise levels surrounding the tractor operator and in open air. Tractor, equipment and environmental conditions were taken into consideration as sources of noise pollution. Intensity of noise pollution caused by those sources was determined at the point where drivers and assistant driver stood. The influence of engine speeds and transmission gears on noise levels were determined. The level of annoyance depends not only the level of the noise but also operator's position and the duration. The levels of the noise when the tractor was in neutral were also measured. Maximum noise level was measured in exhaust as 91.7 dBA while the minimum noise level was at the surrounding of the tractor operator as 79.7 dBA. An increasing of 3 dBA was measured for engine speed changes from 1000 to 2000 rpm.

Key words: Noise, tractor, sound, agriculture

INTRODUCTION

Sound is a common part of daily life and also agricultural mechanization that we rarely distinguish all of its effects. Many sounds that are unpleasant or unwanted are called noise. The noise that annoys us must be prevented in its source or environment that it spreads.

Sound, generally which is generated by men, is the indispensable means of the communication for life. According to this approach, putting forward that noise is the price of industrialization will not be wrong. Noise is accepted as an environmental pollution, during its negative effects increase.

However, noise is not a chemical pollutant. It does not pollute the soil or air and it is neither resident nor infectious. A whisper from the lips or any mechanical sound caused by friction disappears in space but may affect men directly. Sound disappears in space but it remains on people with decreasing of spirit or hearing disabilities. Noise, even the most unimportant, ones might make people quarrelsome and nervous. For this reason, it is necessary to fight seriously against the noise as the other pollutants.

In some countries, especially in the developed ones, noise levels in general environment increase dangerously. For instance, in USA, increasing in noise level is 1 dBA per year. A research done in Ankara, the capital of Turkey, on Noise level showed that an increase of 8-10 dBA was measured within 9 years from 1970 to 1979.

The prohibition of noise is possible at three stages. Some precautions must be taken in the source of noise, in the environment that it spreads and at the target affected.

Effects of noise on men: Noise causes corruption of communication, discomforts and reduces in physical or mental performance. Mostly in workshop and especially in machinery men exposes to high noise. These represent the most severe form of acoustic dangers. Noise in such places may damage the functionality seriously. First of all, hearing disabilities may occur. Hearing disabilities caused by high noise might be temporary or permanent. About 85 dBA and above of noise level can endanger of hearing if it continues for a long time. If it is too impetuous, it could even cause to deafness. In this way, hearing disabilities start at high frequencies at first and then frequency of speech and lower frequencies may be affected. After that the affected person can recognize his disability of hearing.

Generally the effects of noise are hidden at 30-65 dBA. Sounds at 65-85 dBA might cause physical effects beside the physiological effects. These adverse effects on autonomous nervous system can be summarized as increase in blood pressure decrease in heart pulses, getting weak in muscles and withdrawal of blood from skin (Sabancı and Uz, 1984).

Sounds over 85 dBA have effects such as temporary or permanent hearing disabilities. For this reason International Labour Organization (ILO) accepted this level as a warning level.

The harmful effect of noise on men is not only a function of time but also level. According to ILO, the duration at which harmful effects began, are given in Table 1.

The most dangerous opinion which is very common among people is that a person can be accustomed to

Table 1: Period that noise level becomes harmful

dBA	90	92.5	95	97.5	100	102.5	105	110	115
Period (h)	8	6	4	3	2	1.5	1	½	¼

Table 2: Determined noise levels (dBA) relating to tractor + equipment, Ks: values taken from driver's ear level, Yo: values of surrounding the tractor operator (Arin and Celen, 1995)

Tractor+Equipment		Tractor+ field sprayer	Tractor+ chisel plow	Tractor+ grain drills	Tractor+combicrum (harrow+roller)	Tractor+ hoe	Tractor+rotary cultivator
Mean of max. and min.	Ks	92.47	94.65	95.41	96.05	100.14	99.14
the noise levels (dBA)	Yo	92.4	80.85	84.3	90.68	85.61	88.2
CV of the determined	Ks	11.7	3.38	7.33	7.6	1.65	1.38
noise levels	Yo	11	14	70	2.15	1.91	4.36
Standard Deviations of	Ks	1.09	0.32	7	0.73	0.16	0.13
the determined noise levels	Yo	0.94	0.32	6.22	1.95	0.16	0.38

Table 3: Hearing loss according to age groups of drivers (dBA) (Sabancı and Ozsahinoglu, 1985)

	Noise frequencies (kHz)						
Age groups	0.25	0.5	1	2	4	8	Mean (dBA)
25	25	19.27	10.8	10	16.7	22.5	17.36
30	16.5	12.1	12	8.2	13.1	11.5	12.22
35	14.2	9.1	7.1	6.7	12.2	14.5	10.78
40	14.5	9.9	9.4	12	9.2	8.9	10.61
45	12.4	5.1	5.8	3.2	15.9	13.1	9.26
General mean	16.5	11.1	9	8	13.6	14.1	12.07

noise. This believe is totally wrong and accustomed to noise is an evidence of losing hearing abilities. Another dangerous opinion is that noise level is accepted as non-hazardous unless it makes a clink in the ear. It's true that high noise causes such clinks but it is not true that sounds without clinks are below the harmful level.

The noise problem in agriculture: Technological progress, which aims to gain velocity in production, decreased the physical work burden of men but it has some negative effects on increasing of mental problem while it increases the production in fact. The aim in agricultural mechanization that formed by applications in agricultural production of technology provides an increase in men burden mentally while physical work burden decreases. Therefore a person in the system of generation should have more ability and skills. This leads for thinking of machine properties with men properties and limited men abilities together. Otherwise, it affects the expected success of a system while it causes to increase work diseases and accidents.

Arin and Celen (1995) determined noise levels of some farm machines. Noise level results that were found in the research performed with 6 different combinations of a tractor and agricultural equipment that is used are given in Table 2.

The noise levels measured at whole agricultural instruments taken for experiment were determined over 90 dBA accepted as danger limit. Although working 8 hours at the level of 90 dBA noises for a tractor driver is normal, when the noise increases 5 dBA.

Agricultural equipment manufacturers have directed their efforts toward reducing the sound levels at the operator stations of tractors in recent years. Many manufacturers have designed operator stations for tractors that have noise levels below the safe level of 85 dBA at which hearing loss will not occur after 16 h of exposure. Many operator stations of farm tractors are still characterized by noise levels sufficient to constitute a chronic health hazard (Suggs, 1987).

Ear level measurements were performed in cab. If the cab is not used, the strength will be at the ear level of a driver. The noise level at ear level will be 8-10 dBA higher which corresponds100 dBA, considered is a serious danger.

It must not be forgotten that hazards increase more when vibration problem joins with the noise in the agricultural tractors.

The best way for protecting from the harmful effects of the noise is to prevent and to decrease it. It is the responsibility of the planners and the manufactures.

Sabanci *et al.* (1984) researched the negative effects of different noise frequencies at the tractor driver's age of between 25 and 45 at 5 different age groups. Results of this research are presented in Table 3. Relationships between the noise of tractor and the loss of hearing and findings of the research are summarized as below. Tractor noises changed between 75 and 85 dBA. There was a direct connection between motor power and noise. The loss of hearing on a driver was noticed at the youngest age group mostly. The loss of hearing average was found as 12 dBA.

Tractor is a defining input for agricultural mechanization. Noise level is changing between 85 and 117 dBA at the agricultural machines such as combine harvester, atomizer, slope machine, soil shaping machine, baling machine except tractor. But among these machines, there is a problem with the tractors. Because, they have got the longer using time than the other machines. For this reason, use of the best-isolated cab from the noise and vibration is the most important precaution. It is known that the noise level is decreasing between 2-10 dBA mostly with this precaution.

Broste *et al.* (1989) tested 31 tractors for noise at ear elevation in the driver seat without a cap or with cap windows open and only one tractor produced less than 85 dBA at full throttle at Marshfield Clinic. Results of this research indicated the need for continued application of noise reduction techniques to agricultural tractors.

Noise caused by the tractors or other agricultural machines affects only the user. Because the agricultural works are performed outside. Settlements do not cause noise pollution. However, as in industrialized areas, noise-preventing precautions must be herded in agricultural areas.

Meyer *et al.* (1993) measured tractor noise exposure levels for bystanders as described by the Nebraska Tractor Test laboratory and for bean bar riders on ground surfaces of concrete, grass and bean field. The average sound level decreased as the ground cover changed from concrete to grass and then to bean field. An increase of 3dBA was measured for engine speed changes from 1200 to 1500 rpm and 1500 to 2000 rpm. Gear section was determined not to be significant for bystander exposures but bean bar exposures increased as transmission gear changed from the first to the fourth. Noise exposure levels experienced at the bean bar position were on average 10 dBA higher than those measured at the bystander position.

The objective of this research was to measure the sound levels at the surrounding of tractor's operator and at open air for a farm tractor.

MATERIALS AND METHODS

Materials: In this study, noise levels of a tractor at different gear degree were determined. Digital sound level meter of SL 4001 (Arin and Celen, 1995) was used.

As a noise source of a tractor, New Holland L95 was used. Its power is 95HP (70 kW) and revolution is 2500 rpm in maximum power. The tractor has 12 forward gear level and 12 backward gear degrees. Velocity of tractor at engine speed of 2500 rpm shown in Table 4.

Table 4: Velocity of tractor at engine speed of 2500 rpm (km h^{-1})

		Forward gear	Backward gear
1st strengthening gear	1st gear	4.2	4.1
	2nd gear	6.1	6.0
	3rd gear	8.8	8.6
	4th gear	12.6	12.4
2nd strengthening gear	1st gear	1.8	1.8
	2nd gear	2.6	2.6
	3rd gear	3.8	3.7
	4th gear	5.4	5.2
Without strengthening gear	1st gear	9.914	9.7
	2nd gear	20.7	14.1
	3rd gear		20.3
	4th gear	29.7	29.1

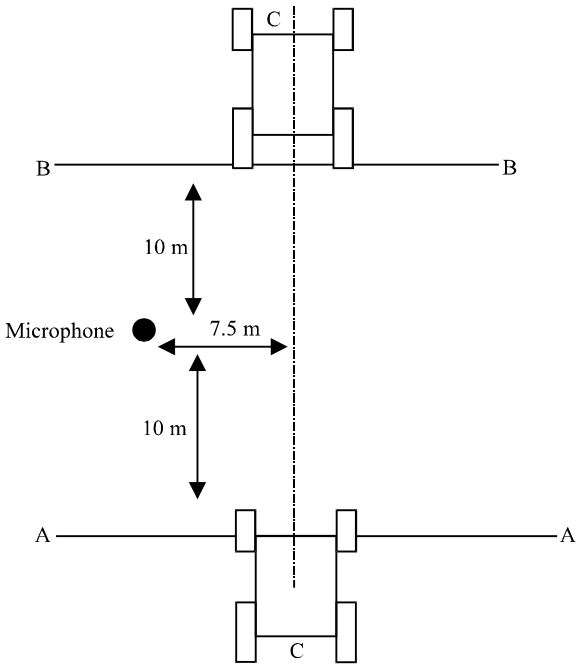

Fig. 1: Prepared system for determining of noise levels at tractor and outside

The test was performed at the fields of Tekirdag Faculty of Agriculture fields. These fields were smooth and did not cause wheel noise (TSE Standards, 1991). Selected fields were in open areas.

Methods: Measurements were made at different points and in different working situations. These situations were:

- ✓ While the tractor was not working
- ✓ At all tractor's gear levels
- ● Driver's ear level
- ● The surrounding the tractor operator
- ✓ While tractor was in neutral
- ● Driver's ear level
- ● The surrounding the tractor operator
- ● Behind the tractor
- ● In front of the tractor
- ● At the outlet of the exhaust

Before starting measurements, the tractor motor was heated to normal running heat.

A microphone was placed on the other area as shown in Fig. 1. The height of the microphone was selected as 1.2 m. As the tractor moving ahead CC line, measurement device was ran when the front of the tractor was at BB line.

Furthermore measurements were taken at driver's ear level. For this aim, measurement device were hold 0.25 m away while tractor was running.

Measurements were taken by holding the device 0.5 m away from the wheel axis, parallel to the ground and 0.5 m high behind and in front of the tractor.

Before measurements, calibration was set and adjusted by 94+0.2 dBA level of the noise values of measurements were determined by eye.

The microphone was located at 0.20 m distances from exhaust. Its angle was 45 degree for vertical axis of the exhaust out. Noise levels were established to separate each gear.

RESULTS

The level of the noise during measurements measured, behind and in front of the tractor, on the exhaust out, in open air, at the surrounding of tractor operator as ear.

The wind blew with a speed of 1.5-3.0 m s^{-1} in the opposite direction and parallel to tractor moving direction during the measurement.

Before measuring, when the tractor was stopped, the level of the noise was measured as 67-63 dBA.

The levels of the noise when the tractor was in neutral are shown in Table 5. It was measured as maximum 91.7 dBA to exhaust and as minimum 79.7 dBA at the surrounding of tractor operator. Noise levels of tractor in the front and in the back were recorded as between 80.6-81.6 and 80.3-80.6 dBA, respectively.

Table 6 shows the level of noise at the surrounding the tractor operator. When the revolution and gear increase, the noise level decreases (Table 5). In addition, using of strengthening gear increased the tractor's noise levels. Determined noise levels at different motor revolution (1000 and 2000 rpm), with strengthening gear and without strengthening gear, at reverse gear, at surrounding the tractor operator and open air, are shown in Fig. 2. These results in Table 6 indicated that noise levels were increased at 2000 rpm and exceeded safe limit of 85 dBA.

Table 7 shows recorded noise levels in open air. Determined noise levels at the surrounding tractor operator were higher than the noise levels in open air.

Fig. 3 shows the maximum noise level at surrounding the tractor operator and in open air recorded for the first (a) and the fourth (b) transmission gear. Maximum noise levels were found for the first transmission gear as 88.1 dBA at 2000 rpm engine speed and 1st strengthening gear. It was 92.4 dBA for the fourth transmission gear at 2000 rpm engine speed and without strengthening gear at the surrounding the tractor operator. Maximum noise

Table 5: The levels of the noise when the tractor was in neutral

	Front		Back		The surrounding the tractor operator		Exhaust	
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.
Noise level (dBA)	80.6	81.6	80.3	80.6	79.7	80.4	90.7	91.7

Table 6: Determined noise levels at different engine speed (1000 and 2000 rpm), with strengthening gear and without strengthening gear, at reverse gear, at surrounding the tractor operator

	rpm		1st gear	2nd gear	3rd gear	4th gear
Without strengthening gear	1000	Min	78.3	79.4	79.1	81
		Max	81.2	82.9	82.4	84.1
	2000	Min	86.8	86	86.5	87.8
		Max	87.2	90.7	89.7	92.4
1st strengthening gear	1000	Min	76.5	79.2	80	79.7
		Max	79.3	80.9	82.3	79.9
	2000	Min	85.3	85.6	85.6	86.1
		Max	85.4	87.1	90.4	87.2
2nd strengthening gear	1000	Min	79	79.4	79.1	79.5
		Max	79.6	79.9	82.6	81.3
	2000	Min	85.4	86.1	86.1	86.4
		Max	88.1	88.6	88	87.6
Reverse gear	1000	Min	79.5	80.3	79.4	79.2
		Max	80	81.2	81.4	82.4
	2000	Min	84.7	84.6	84.5	85.4
		Max	88	89.2	89.8	88.7

Table 7: Measured noise level in open air

	rpm		1st gear	2nd gear	3rd gear	4th gear
Without strengthening gear	1000	Min	63.2	68.2	69.2	64.5
		Max	77.3	76	76.4	76.6
	2000	Min	72.4	75.1	72.2	73.3
		Max	81	82.3	82.2	82.2
1st strengthening gear	1000	Min	65	65.4	67	66.9
		Max	75.8	75.6	76.3	76.9
	2000	Min	72.4	72.9	72.8	73.1
		Max	79.8	81.8	80.2	79.5
2nd strengthening gear	1000	Min	67	67.3	67.1	67.3
		Max	75.1	74.8	74.7	76
	2000	Min	72.7	73.4	73.7	73.6
		Max	79.5	79.7	79.6	79.7
Reverse gear	1000	Min	66.4	68.9	66.5	66.2
		Max	80.1	77.1	79.7	77.2
	2000	Min	72.8	75.4	74.4	67.8
		Max	79.3	83.5	80.2	82

Table 8: Equivalent A-weighted sound level for corresponding noise dose values (Thrumann, 1990)

Sound level (dBA)	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100
Noise dose(%)	50	57	66	76	87	100	115	131	152	174	200	230	264	283	355	400

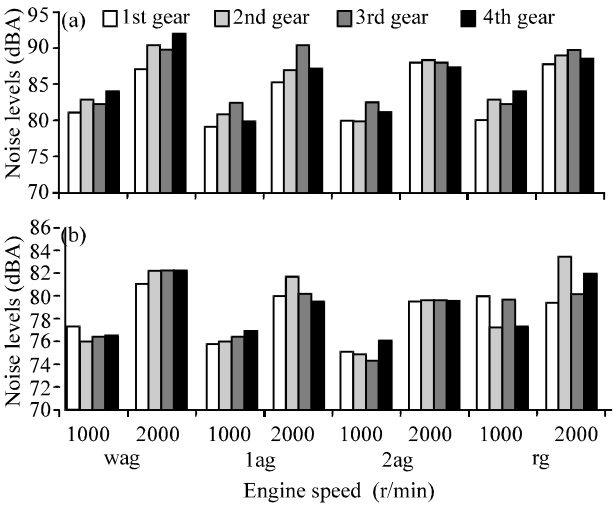

Fig. 2: (a) at surrounding the tractor operator, (b) at open air, determined maximum noise levels at different engine speed (1000 and 2000 rpm); 1ag, 1st strengthening gear; 2ag, 2nd strengthening gear; wag, without strengthening gear; rg, at reverse gear

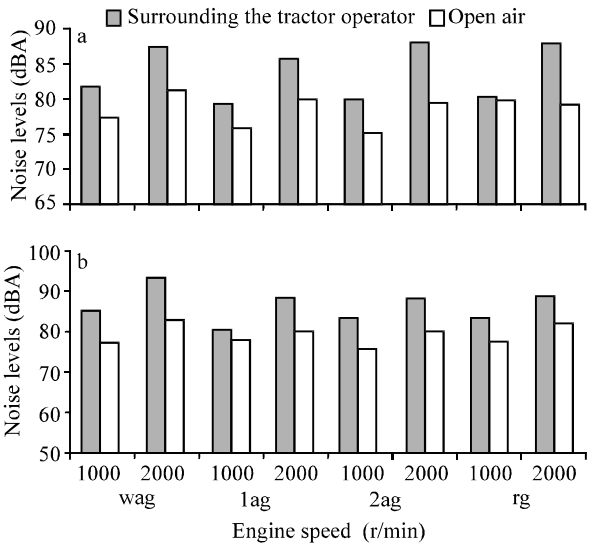

Fig. 3: Measured maximum noise levels at 1000 and 2000 rpm engine speed, at surrounding the tractor operator and in open air; (a) for the first transmission gear;(b) forth fourth transmission gear; 1ag, 1st strengthening gear; 2ag, 2nd strengthening gear; wag, without strengthening gear; rg, at reverse transmission gear

level for first transmission gear was 80.1 dBA at 2000 rpm engine speed and reverse transmission gear. It was 82.2 dBA for the fourth transmission gear at 2000 rpm engine speed and without strengthening gear. These results indicated that maximum noise levels were determined at without strengthening gear with 2000 rpm when the selected gears increased from the first to the fourth. Noise levels (1st and 4th transmission gear) in open air were below the safe level of 85 dBA in all situations. It was exceeded at surrounding the tractor operator at the same transmission gears.

The equivalent A-weighted sound level determined from the noise dose values using Table 8 were approximately 90.7 dBA for surrounding the tractor operator and 83.5 dBA for open air. The result of the project dose was 110% for surrounding the tractor operator and less than 50% for open air.

Noise levels experienced by tractor are likely to be 85 dBA safe limit. Measurement results on transmission gears showed differences. When the tractor was stopped,

the noise levels were measured as maximum 67 dBA in open air. At the other situations (at surrounding of the tractor, in the back, in the front of tractor) noise levels were below safe limit. This limit was between 90.7-91.7 dBA and above the safe limit at exhaust when the tractor was in neutral.

Engine speeds and motor revolutions influenced the noise levels in open air and surrounding tractor operator. The noise level in open air was below the safe limit. Generally sound levels at 2000 rpm with strengthening gear showed an increase. There was a 3 dBA increase in noise level from 1000 to 2000 rpm.

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