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Noise Levels of Various Agricultural Machineries

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Abstract: Sound is such a common part of everyday life and also agricultural mechanization that we rarely distinguish all of its effects many sounds are unpleasant or unwanted, these are called noise since the noise annoys us must be prevented in source, while spreading and at the target. In this study, noise levels of various agricultural machines combined with a tractor measured with a digital sound level meter. The level of annoyance depend not only the level of the noise but also operator's position and duration. Maximum noise level was measured as 96.6 dBA at surrounding the tractor operator while the minimum noise level was in open air as 67.7 dBA. An increasing of 6 dBA was measured for engine speed changes from 1000 to 2000 rpm.

Key words: Noise, agricultural machine, sound, agricultural

INTRODUCTION

Sound is radiant energy that is transmitted through space by longitudinal pressure and is the objective cause of hearing. Normal ears can detect sounds of minute intensity as well as extreme intensity. Noise is best described as unwanted sound of sufficient intensity to damage hearing. The measurement of sound or noise is related to pressure, frequency and duration and is commonly measured in units called decibels.

Environmental noise can affect people both physically and psychologically. Physical damage, such as loss of hearing, is rare outside the work place, since noise is not often concentrated from one source for long enough. In the work place continuous processes make it more likely that physical damage will occur, especially when the noise is experienced over prolonged periods. Continuous exposure to noise levels above 85 dBA can result in some permanent loss of hearing. Outside work, people are mainly affected psychologically. High frequency noise has also been claimed to make people irritable and angry. Noise can interfere with speech and communication and disturb sleep.

Generally the effects of noise are hidden at 30-65 dBA. Sounds over 85 dBA might cause physical effect 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[1].

Sound 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. Table 1 shows how many hours a person can safely be exposed to sound at certain volume levels. These time limits are based on guidelines for industrial workers in Regulations of the Occupational Safety and Health Administration.

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

Occupational noise levels are a problem in agriculture. The sources of noise on the farm are as varied as the farms across this province. Prolonged exposure to noise can lead to a gradual loss of hearing. Major sources of noise on the farm may include machinery, small engines

Table 1: Period that noise level becomes harmful

Maximum duration per day hours	Sound level (dBA)
8	90
4	95
2	100
1	105
½	110
¼	115

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Table 2: Typical noise level on the farm[10]

Noise source	Tractor	Grain dryer	Combine	Chainsaw	Grain grinding	Pig squeals	Orchard sprayer	Riding mower	Garden tractor	Crop dusting aircraft
Noise level (dBA)	74-112	81-102	80-105	77-120	93-97	85-115	85-106	79-89	88-94	83-116

Table 3: Determined noise levels (dBA) relating to tractor+equipment, Ks: values taken from driver's ear level, Yo: values of surrounding the tractor operator[4]

Tractor+Equipment		Tractor+field sprayer	Tractor+chisel plow	Tractor+grain drills	Tractor+combicurum (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	92.40	80.85	84.30	90.68	85.61	88.20
CV of the determined	Ks	11.70	3.38	7.33	7.60	1.65	1.38
noise levels	Yo	11.00	14.00	70.00	2.15	1.91	4.36
Standard deviations of the	Ks	1.09	0.32	7.00	0.73	0.16	0.13
determined noise levels	Yo	0.94	0.32	6.22	1.95	0.16	0.38

Table 4: Hearing loss according to age groups of drivers (dBA)[11]

	Noise frequencies (KHz)						
Age groups	0.25	0.5	1	2	4	8	Mean (dBA)
25	25.0	19.27	10.8	10.0	16.7	22.5	17.36
30	16.5	12.10	12.0	8.2	13.1	11.5	12.22
35	14.2	9.10	7.1	6.7	12.2	14.5	10.78
40	14.5	9.90	9.4	12.0	9.2	8.9	10.61
45	12.4	5.10	5.8	3.2	15.9	13.1	9.26
General mean	16.5	11.10	9.0	8.0	13.6	14.1	12.07

and power tools. Large machinery such as tractors and combines emit noise levels of 80 to 150 dB. Two-cycle engines such as lawn mowers and chain saws can damage hearing with repeated exposure. In addition, heaters, generators and radios inside the cabs of tractors and combines can emit high noise levels that may damage hearing. Table 2 shows the noise levels of various sources. The potential for loud noise to cause a hearing loss depends on how loud the noise is and how long a person is exposed to the noise. As the work environment gets louder, the amount of time a person can safely work there without permanent damage to hearing gets shorter.

Farmers work in conditions that frequently expose them to high noise levels. Their risk of sustaining a noise-induced hearing loss can be reduced or prevented by first identifying sources of loud noise, then by taking steps to reduce exposure to those sources.

More and more studies show that farmers are at a higher risk for developing hearing impairments than the rest of the population. The main cause of hearing loss among farmers is thought to be noise exposure from on-jobs, not industrial noise exposure from off-farm jobs.

Noise in the agricultural environment is not a new hazard. From 1981 to 1983, in the United States 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. For the purpose of NOES, workers were considered to be noise-exposed if the noise levels were 85 dBA or greater, regardless of the exposure duration[2].

Occupational exposure to noise is determined by the value of acoustic energy and the duration of exposure-a parameter which is especially important while considering exposure to noise among private farmers. This is associated with its great variability, almost every day throughout the whole year, as well as with the presence in the rural environment of a large number of various source of noise, e.g. agricultural tractors of various types, self-propelled agricultural machines, machinery for the production of fodder, workshop machinery or circular saw. The studies conducted previously showed that the greatest risk for the organ of hearing is caused by medium and low-power tractors (84-101 dBA) which are most frequently used on private farms, as well as by combine harvesters (88-92 dBA). High power tractors produce considerably lower level of noise[3].

Arın and Celen[4] 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 3.

The noise levels measured at whole agricultural instruments taken for experiment were determined over 90 dBA accepted as danger limit. Although working 8 h at 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[5].

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 corresponds 100 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 manufacturers.

Sabancı *et al.*[6] 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 4. 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 85-117 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.*[7] 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 indicate 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 workings 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.*[8] 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 3 dBA was measured for engine speed changes from 1200 to 1500 and 1500 to 2000 rpm. Gear section was determined not to be significant for by stander 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 noise levels at the surrounding of tractor's operator and at open air for farm machinery.

MATERIALS AND METHODS

Description of the equipment: As a noise source of a tractor, New Holland L95 was used. It power is 95 HP (70 kW) and revolution is 2500 rpm in maximum power. The tractor has 12 forward gear level and 12 backward gear degrees. Used farm machines are shown Table 5.

Test measurements and test conditions: The test was performed at fields of Tekirdag Faculty of Agriculture fields. These fields were smooth and did not cause wheel noise[9]. Selected fields are in open areas.

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

1. At driver's ear level,
2. At idle position of a tractor,
3. When tractor running as equipped and not equipped,

Noise level is measured with the tractor and machine moving over the ground at the recommended machine operating speed and engine speed.

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 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 in behind and 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

Table 5: Specification of various agricultural machineries

Machines	Specifications	Machines	Specifications
Fertilizer broadcaster	Hooper capacity: 320 kg	Pneumatic precision drill	4 rows
	Weight of machine: 100 kg		Working width: 295 cm
	Height: 182 cm		Weight: 700 kg
Combicrum	21 spring tines+roller	Subsoiler	Working depth: 60 cm
	Working width: 250 cm		Overall width: 100 cm
	Weight: 520 kg		Weight: 260 kg
Mechanical seed drill	16 rows	Chisel plough	7 rigid tines
	Working width: 240 cm		Working width: 198 cm
	Weight: 610 kg		Weight: 420 kg
Baler	Width: 270 cm	Plough	3 furrow plough
	Weight: 2535 kg		Working width: 82 cm
	Bale dimension: 36x46		Weight: 420 kg

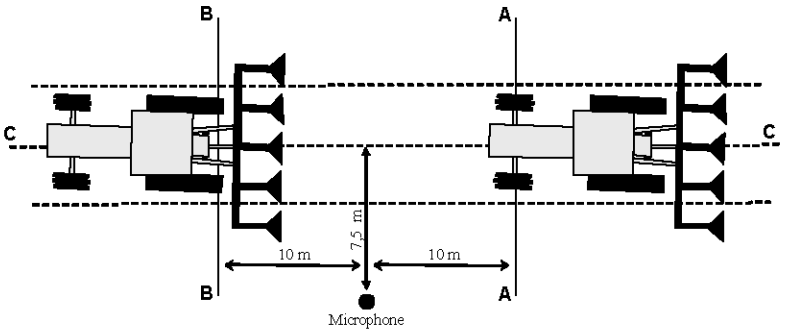

Fig. 1: Prepared system for determining of noise levels at tractor and outside

exhaust out. Noise levels were established to separate each gear.

Instruments used: Digital sound level meter of SL 4001[4] was used. Sound Level Meter model SL-4001, Digital 3½ digit LCD display, 18 mm size, function dB (A and C weight) fast, slow, Max hold AC/DC output measuring range A weight 30-130 dB C weight 35 to 130 dB range selector 30 to 80 dB, 50 to 100 dB, with 80 to 130 dB, with electric condenser microphone. Frequency 31.5 to 8000 Hz.

Digital anemometer of AM 4201 was used. Anemometer Lutron model AM-4201 3½ digit L. C. D. Portable, fast high accurate readability measurement 0.2 to 40.0 m s^{-1}, 0.7 to 144.0 km h^{-1}, 40 to 7870 f min^{-1}, 0.4 to 77.7 Knots with Data Hold function.

Digital humidity/temp. meter of HT 3003 was used. 3½ digit L. C. D. Portable. The data hold feature stores both the RH and temperature. 0.4 seconds sampling time. Operating humidity and temp: 0 to 50°C (32 to 122 °F) and 90% RH max.

RESULTS

The level of the noise during measurements measured, in open air, at the surrounding of tractor operator as ear.

The wind blew with a speed of 2.5-8.2 m s^{-1} in the opposite direction and parallel to tractor moving direction during 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 6. It was measured as maximum 91.7 dBA to exhaust and as minimum 79.7 dBA at the surrounding of the tractor operator. Noise levels of the front and in the back were recorded as between 80.6- 81.6 and 80.3-80.6 dBA, respectively.

Table 7 shows the noise levels of farm machines in different work conditions. These conditions were selected as suitable for farm machines related with farm working. Maximum noise levels were found as 96.6 dBA at 2nd gear level at 2000 rpm at surrounding the tractor operator for pneumatic precision drill. Minimum noise levels were found as 67.7 dBA at 2nd gear level at 1000 rpm in open air for fertilizer broadcaster.

Figure 2 shows the maximum noise level at surrounding the tractor operator and in open air recorded at 1000 rpm engine speed for farm machinery. Maximum noise levels were found for the mechanic seed drill as 91.3 dBA at the surrounding the tractor operator. It was 84.3 dBA for the open air at mechanic seed drill. Noise levels for farm machinery 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 situations.

Table 6: The levels of the noise when the tractor was out of gear[12]

	The surrounding of the tractor							
	Front		Back		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 7: Determinated noise levels (dBA) for some farm machines in different conditions

		Noise levels (dBA)							
		Open air		Driver's ear					
Agricultural machinery	Gear position	1000 (rpm)	2000 (rpm)	1000 (rpm)	2000 (rpm)	Humidity (%)	Temp. (°C)	Wind speed and direction (m s^{-1})	Tractor direction
Fertilizer broadcaster	1st gear	68.0-75.6	74.4-82.1	83.4-84.2	90.2-91.2	61.6	28	3 →	←
	2nd gear	67.7-75.1	74.6-82.3	83.5-84.1	90.2-91.3				
Combicurum	1st gear	69.5-75.1	74.8-82.4	80.0-83.1	86.0-89.6	70.0	25	4-4.6 ←	←
	2nd gear	69.6-76.1	74.8-83.7	81.7-85.9	90.0-91.6				
Mechanic seed drill	1st gear	68.0-76.2	-	81.0-88.1	-	70.0	25	4-4.6 ←	←
	2nd gear	75.0-84.3	-	88.0-91.3	-				
Baler	1st gear	75.3-82	83.0-85.1	89.6-90.5	90.9-91.8	61.1	24	3 ↑	←
Pneumatic presicion drill	1st gear	69.9-74.5	70.2-85.5	82-83.7	90.6-96.6	62.0	29	2.5-3.5 →	←
	2nd gear	70.3-73.6	73.9-80.9	83.3-85.7	93.8-96.6				
Subsoiler	1st gear	70.5-74.7	74.9-79.7	79.3-85.2	88.2-90.6	62.0	29	2.5-3.5 →	←
	2nd addit. 4th gear	69.8-74.9	74.2-80.8	80.3-85.4	89.3-91.2				
Chisel plough	2nd addit. 3rd gear	-	73.2-79.2	-	88.2-91.9	62.0	29	2.5-3.5 →	←
	2nd addit. 4th gear	-	73.5-81.4	-	89-92.4				
Plough	1st gear 4x4 1st addit.	-	86.3-90.9	-	76.5-83.6	65.0	30	4.5-8.2 ←	←
	4th gear 4x4	-	86.5-88.3	-	76.6-81.8				

Table 8: Equivalent A-weighted sound level for corresponding noise dose values

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

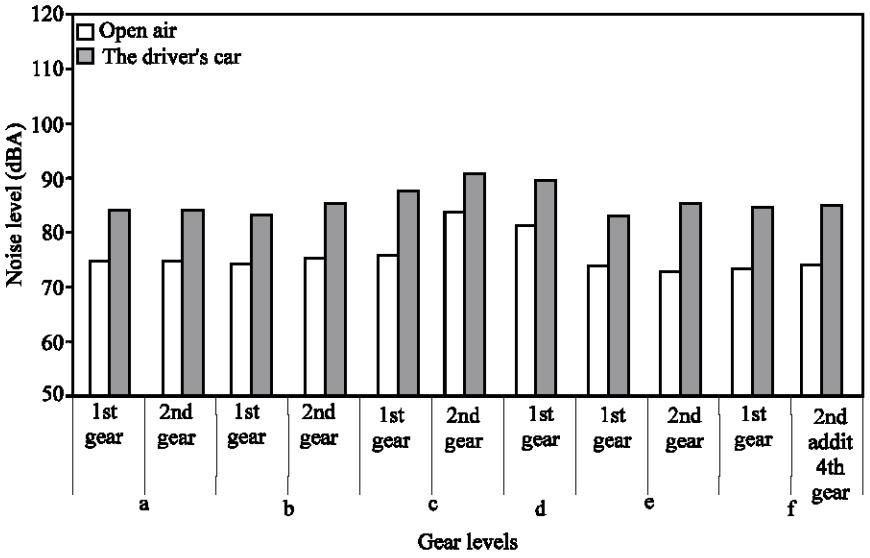

Fig. 2: Measured maximum noise levels at 1000 rpm engine speed, at surrounding the tractor operator and in open air
a. Fertilizer broadcaster b. Combicurum c. Mechanic seed drill d. Baler e. Pneumatic precision drill
f. Subsoiler

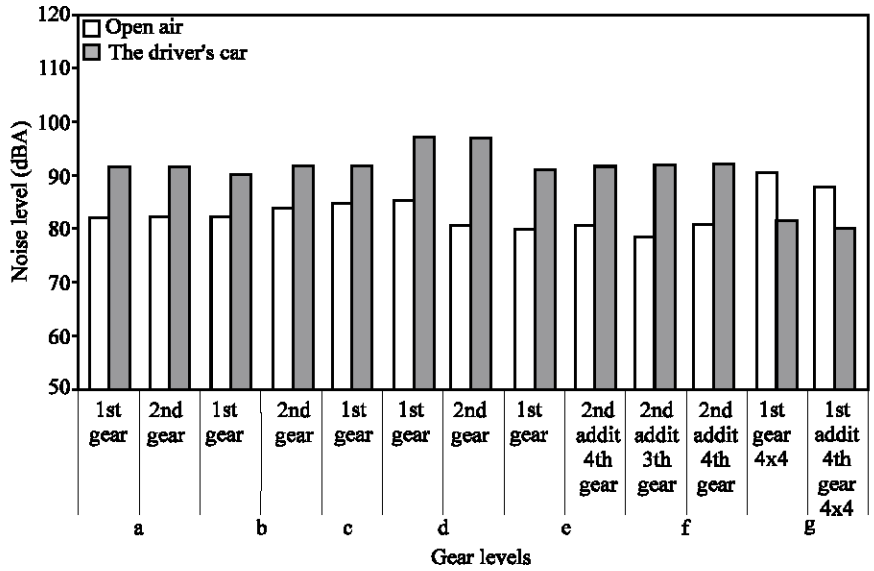

Fig. 3: Measured maximum noise levels at 2000 rpm engine speed, at surrounding the tractor operator and in open air
a. Fertilizer broadcaster b. Combicurum c. Baler d. Pneumatic precision drill e. Subsoiler
f. Chisel plough g. Plough

Figure 3 shows the maximum noise level at surrounding the tractor operator and in open air recorded at 2000 rpm engine speed for farm machinery. Maximum noise levels were found for the pneumatic precision drill as 96.6 dBA at the surrounding the tractor operator. It was 90.9 dBA for the open air at plough. Noise levels for farm machinery in open air and surrounding the tractor operator were above the safe level of 85 dBA in all situations.

The equivalent A-weighted sound level determined from the noise dose values using Table 8 were approximately 96.6 dBA for surrounding the tractor operator and 90.9 dBA for open air. The result of the project dose was 250% for surrounding the tractor and 113, 5% for open air.

Noise levels experienced by tractor are likely to be 85 dBA safe limits. 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 surrounding of the tractor noise levels were below safe limits.

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 showed an increase. There was a 6 dBA increase in noise level from 1000 to 2000 rpm.

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