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EFFECT OF FUEL TYPE, ANGLE OF COVER PLATE AND FORWARD SPEED ON TRACTOR PERFORMANCE

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Abstract

In this experiment two levels of types fuel diesel (1 and 2), three levels of the angles of cover plate (45, 60 and 75) ° and three levels of the tractor forward speeds (2.51, 4.35 and 6.87) km/hr were investigated, the experiment studied impact of these factors on the noise, slipping, fuel consumption and productivity. The experiment was conducted in a field of the College of agricultural engineering sciences at the University of Duhok. The tractor type BAŞAK model 2073, with the power 53 HP (38.96 kW) and horizontal rotary plow was used. The results showed that the difference in between the type of fuel, angles of cover plate and forward speed were significant differences. The interaction between the diesel fuel 2, angle of cover plate 75° and forward speed 2.51 km/hr recorded the lowest values for noise, slipping and fuel consumption (97.2 dB,13.3% and 6.0 L/ha) respectively. The same treatment gave highest productivity 0.068 ha/hr.

Key Words: noise, fuel consumption, slip, productivity, rotary plow, forward speed, tractor

1 INTRODUCTION

Noise in agriculture is relevant risk factor to be taken into account in evaluating health and safety of workers. In fact, one of the major sources of discomfort for workers operating a tractor is the noise that occurs during work [1]. Even with technology advancement in the production of agricultural equipment, the noise level is still too high for an 8-hour tractor drive without cab protection, necessitating the use of hearing protection [2]. The rotary plow and the spreader contributed to the increase of noise levels observed, especially at the tractor rear [3]. The parameters, such engine rotational speed and the fuel type, had an effect on noise pollution at a level of 1% and that the fuel type almost had a 5% impact on it, both as the driver and a bystander [4]. The engine speed and fuel type have effect significant ($P < 0.01$) effect on tractor noise, the noise increased as forward speed increased [5].

Tractors performance for plowing operation depends on forward speed, plowing depth and type of the tractor. However, the depth of crop roots should determine the appropriate plowing depth in order to minimize expenses for fuel consumption [6]. The cost of fuel significantly affects the input costs of agriculture production, especially during primary tillage, and affected by a different of parameters such as types of plows, depths of plowing, and tractor forward speed [7]. The fuel consumption is a better indication of the amount of energy needed for each implement. The increase in forward speed caused the trundling to increase, which in effect increased the required capacity

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to reduce a certain distance as well as the fuel consumption. The highest value of the fuel consumption was 7.9 l/hr at 4.33 km/hr [8]. When the forward speed increased from 0.24 to 0.30 m/sec, the fuel consumption increased from 2.13 to 2.75 kg/hr. This result was due to that increased the tractor forward speed required more fuel consumption [9]. The higher fuel consumption value was 8.84 l/h at forward speed 3.0 km/hr with 12 cm depth of cut [10]. The rotary plow was recorded the lowest fuel consumption rate and the best fragmentation degree of the soil which was 14.42 L. ha-1, 6.5 mm respectively, [11]. The rotary plow for 10 cm depth and 4.5 km/h forward speed gave low fuel consumption (17.22 L.fed-1) [12]. Increased forward speed from 1.15 m/s to 4.9 m/s with 13 cm of plowing depth by the rotary plow, led to decreased fuel consumption about 18.4% [13].

The tractor wheel slippage is a critical parameter for the fuel consumption and field performance and optimally it should be in the range of 8-12% and should not exceed 15% [14]. Increasing the forward speed from 5.5 to 6.3 and then to 7.5 km/h resulted in to an increase in the slipping percentage from 8.28 to 11.48 and then to 17.01% [15]. Increasing forward speed from 4.24 to 5.54 and 6.75 km/h lead to increased slippage percentage from 13.52 to 20.16 and 23.06 % and increased fuel consumption [16] stated that the speed of plowing is of great importance in increasing the actual productivity of the mechanical unit as the practical speed of the tractor is directly proportional to the practical productivity of the mechanical unit [17]. Increased the forward speed of the tractor has led to increasing in the productivity, and decreased the slip percentage [18]. Increasing the forward speed from 3.77 to 5.19 and then 6.45 km/hr led to increase the productivity of a tractor [19]. The forward speed 9.23 km/hr was significantly effect and gave the highest productivity of rotary plow [20].

2 MATERIAL AND METHODS

This experiment was carried out on the field of the college of agriculture engineering sciences at University of Duhok, using BAŞAK tractor model 2073 by the power 53 HP (38.96 kW), the speed power take off shaft 540 r. p. m., with horizontal rotary plow contain made in Turkish, contain 48 rotating blades of L-shape fixed on rotating shaft in 8 groups, working width of plow 160 cm. The total diameter of the rotating shaft and blades is 45 cm, and there is a clearance of 10 cm with the protective cover plate. Two levels type of the diesel fuel (1 and 2) table (1), with three levels of angle cover plate of rotary plow (45, 60 and 75)° and three levels of forward speed (2.51, 4.35 and 6.87) km/hr were examined on some mechanical properties such as noise, slipping, fuel consumption and productivity.

The data were statistically analyzed according to split – split plot design, the main plots were used for types of diesel fuel and split plots were used for angle of the cover plate of rotary plow and split – split plots were used for forward speed of agricultural tractor,

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with three replications for each treatment. The tape 2 m Used to measure the width of the plow. For stop watch was used measuring time in accurately 0.01 sec, and a digital sound level meter SL 4001 was used to measure noise levels produced by the tractor and plow, and fuel consumption system Fig. (1) Used to measure fuel consumption. The data were analyzed using SAS 2000, the properties was calculated using the following relations [21]:

$$CW\% = \left(\frac{W1}{W2}\right) \times 100$$

$CW\% = \text{Coefficient of width}$

$W1 = \text{Actual width} \quad cm$

$W2 = \text{Theoretical width} \quad cm$

$$CS\% = \left(\frac{S1}{S2}\right) \times 100$$

$CS\% = \text{Coefficient of speed}$

$S1 = \text{Speed with load} \quad km/hr$

$S2 = \text{Speed without load} \quad km/hr$

$$Slip\% = \left(\frac{(S1 - S2)}{S2}\right) \times 100$$

$$FE\% = \left(\frac{CW\%}{CS\%}\right) \times 100$$

$FE = \text{Field Efficiency}$

$$P = \left(\frac{S1 \times W1 \times FE}{10000}\right)$$

$P = \text{Production ha/hr}$

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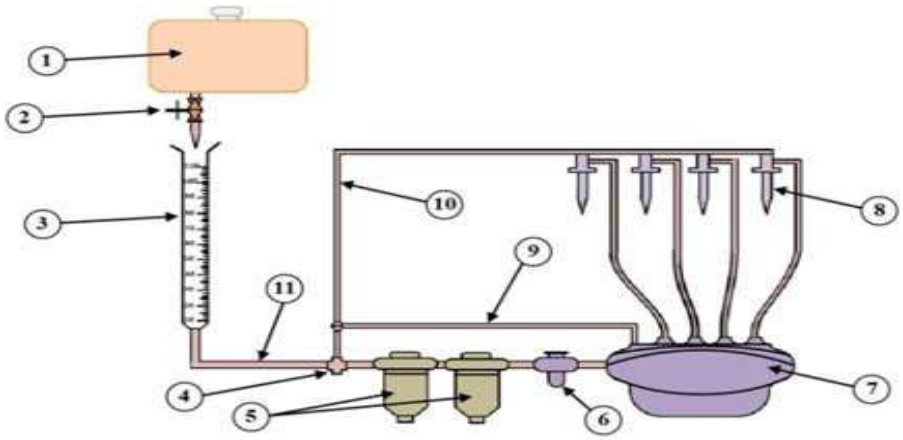
Table (1): Some characters of fuel diesel

Fuel diesel 1		Fuel diesel 2	
Specific Gravity, 15.5° C g/ccm	0.823	Specific Gravity, 15.5° C g/ccm	0.850
Flash point	69	Flash point min.	60
Carbon residue Wt %	0.4	Carbon residue Wt %	0.2
Viscosity cst, 40° C	5.9	Viscosity cst, 40° C	5.6
Pour point	-9	Pour point	-9
Contain index min.	49	Contain index min.	45
Free water %	0.3	Free water %	0.2
Calorific value (Kcal/kg)	10500	Calorific value (Kcal/kg)	10800

Fig. (1): Fuel consumption system



1.Fuel tank 2. Fuel valve. 3. Graduated cylinder 4. Valve 5. Fuel filter. 6. Helpful fuel pump 7.Feeding 8. Injections pump 9. Tube of excess from main fuel pump. 10. Tube of excess from injection. 11. Main plastic tube.

3 RESULTS AND DISCUSSION

3.1 Effect of study parameters on noise

Table (2) shows the effect of type of fuel diesel, angles of cover plate and forward speed, and their interaction on the noise. Effect of the main factor which is type of fuel diesel showed that the fuel diesel 2 had significant differences compare to the fuel diesel 1. The lower value of noise 98.3 dB was observed in the fuel diesel 2 while 99.1 dB is noticed in the fuel diesel 1, whereas angles of cover plate had no significant effect on this parameter. The first level of forward speed 2.51km/hr had significant affect on the noise, which gave the lower value 97.9 dB compare to other treatment levels. The interaction between fuel diesel and angles of cover plate of the fuel diesel 2 and angles

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of cover plate 75° was significantly differ, the minimum noise value 97.9 dB compare to the higher value, which was 100.6 dB. As well, the interaction between type of fuel and forward speed found that the fuel diesel 2 and forward speed 2.51 km/hr was significant in affected the noise, the lowest noise value was 97.8 dB at diesel fuel 2 and 2.51 km/hr of speed, while the highest noise of 100.3 dB recorded with diesel fuel 1 and 6.87 km/hr of forward speed, the result agreed with [4]. Meanwhile, the interaction between angles of cover plate and forward speeds significantly affected the noise the highest value of 100.9 dB at 45° and 6.87 km/hr of forward speed, while the lowest noise value was 97.3 dB at 75° and 2.51 km/hr of speed. The combination between of diesel fuel 2, angle of cover plate 75° and speed forward 2.51 km/hr was superior and gave lowest noise value which was 97.2 dB, whereas the highest value 102 dB at diesel fuel 1, angles of cover plate of 45° and tractor speed 6.87 km/h.

Table (2): Effect of study parameters on noise db

Type of diesel fuel	Angle of cover plate	Forward speed km/hr			Type of fuel * Angle of cover plate	Type of fuel
		2.51	4.35	6.87		
Fuel diesel 1	45°	98.8 cd	100.5 e	102.6 f	100.6 c	99.1 b
	60°	97.8 ab	98.9 cd	99.5 d	98.7 b	
	75°	97.3 a	98.2 bc	98.8 cd	98.1 ab	
Fuel diesel 2	45°	98.4 bc	98.6 c	99.2	98.7 b	98.3 a
	60°	97.6 ab	98.3 bc	98.7 c	98.2 ab	
	75°	97.2 a	97.9 b	98.4 bc	97.9 a	
Type of fuel * Forward speed	Diesel 1	97.9 a	99.2 d	100.3 e	Angle of cover plate	
	Diesel 2	97.8 a	98.2 b	98.8 c		
Angle of cover plate * Forward speed	45°	98.6 bc	99.6 d	100.9 e	98.2 a	
	60°	97.7 ab	98.6 bc	99.1 c	98.3 a	
	75°	97.3 a	98.1 b	98.6 bc	98.4 a	
Forward speed km/hr		97.9 a	98.8 b	99.5 c		

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3.2 Effects of study factors on slipping %

The data presented in table (3) revealed the effect of type of fuel diesel, angles of cover plate and forward speed, and their interaction on slipping %. The effect of the type of fuel diesel showed that the fuel diesel 2 had significant differences compare to the fuel diesel 1. The lower value of noise 14.4% was observed in the fuel diesel 2 while 15.3 % is noticed in the fuel diesel 1. Also the angle of cover plate result had significant differences in this parameter, where the minimum value was at the angle of cover plate 75° to the maximum value 15.6 % in 45° of angle of cover plate. About the impact of forward speed on the slipping, there was significant change on the slipping, the forward speed show that 2.51 km/hr obtained the lowest slippage 14.1% comparing with other speeds. Because speed and rolling resistance are directly inversely related, increasing the tractor forward speeds will result in more rolling resistance and a higher percentage of slippage.

Table (3): Effect of study parameters on slipping %

Type of diesel fuel	Angle of cover plate	Forward speed km/hr			Type of fuel * Angle of cover plate	Type of fuel
		2.51	4.35	6.87		
Fuel diesel 1	45°	14.9 c	15.5 d	17.8 f	16.1 d	15.3 b
	60°	14.1 b	15.3 cd	16.5 e	15.3 c	
	75°	13.5 a	14.9 c	15.5 d	14.6 bc	
Fuel diesel 2	45°	14.4 bc	15.3 cd	15.7 de	15.1 c	14.4 a
	60°	13.8 ab	14.2 b	14.9 c	14.3 b	
	75°	13.3 a	14.1 b	14.2 b	13.8 a	
Type of fuel * Forward speed	Diesel 1	14.2 ab	15.2 c	16.6 d	Angle of cover plate	
	Diesel 2	13.2 a	14.5 b	14.9 c		
Angle of cover plate * Forward speed	45°	14.7 b	15.4 c	16.8 d	15.6 b	
	60°	14.1 ab	14.8 b	15.7 c	14.9 ab	
	75°	13.4 a	14.5 ab	14.9 b	14.3 a	
Forward speed km/hr		14.1 a	14.9 b	15.8 c		

The binary interaction between type of fuel diesel angle of cover plate showed the best slip was 13.8% with fuel diesel 2 and angle of cover plate 75°, while the highest value of slip was 16.1% at fuel diesel 1 and angle of cover plate 45°. The interaction between type of diesel fuel and forward speed given best slip 13.2% at diesel fuel 2 and 2.51

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km/hr of speed, while the highest value 16.6 % at diesel fuel 1 and 6.87 km/hr of speed. Also, the interaction of angle of cover plate and forward speed obtained the superior slip 13.4% at speed of 2.51 km/hr and angle of cover plate of 75°, whereas the highest value 16.8% with 6.87 km/hr of speed and 45° of angle of cover plate. The combination interaction between treatments significantly affected slipping, the lowest value showed between interaction fuel diesels 2, angle of cover plate 75° and forward speed 2.51 km/hr to which was 13.3%.

3.3 Effects of study factors on fuel consumption L/ha

Results in table (4) reported that fuel consumption was significantly influenced by type of fuel diesel. The lower value of fuel consumption was 11.93 L/ha with fuel diesel 2, while the fuel diesel 1 obtained highest value fuel consumption was 13.03 L/ha. The reason for these results may be due to the fuel diesel 1 which led to increase wheel slip. Also the forward speed had significantly effect on fuel consumption, the speed of 2.51 km/hr obtained the lower fuel consumption 7.2 L/ha compared with speed of 6.87 km/hr which obtained the highest fuel consumption 19.4 L/ha. Because the increase in forward speed increased the engine rotation, which increased fuel consumption, the result agreed with [16], Angles of cover plate resulted in no significant differences in this parameter. The interaction between types of fuel and angles of cover plate resulted in significant differences in fuel consumption where the lowest value was recorded in the diesel fuel 2 and angles of cover plate 75° which obtained 11.4 L/ha, while the highest fuel consumption was 13.7 L/ha with diesel fuel 1 and angles of cover plate of 45°. The interaction between types of fuel and forward speeds showed a significant influence on consumption, the lowest value 6.7 L/ha at diesel fuel 2 and speed 2.51 km/hr, while the highest fuel consumption of 19.9 L/ha at diesel fuel 1 and speed 6.87 km/hr. Also the interaction between angle of cover plates and forward speeds recorded a significant impact on fuel consumption, the highest value fuel consumption was 20.4 L/ha with speed 6.87 km/hr and angle of cover plate 45°. While lowest value fuel consumption was 6.6 L/ha with speed 2.51 km/hr and 75° angle of cover plate. About the triple interaction, the results found that there were significant differences between treatments in fuel consumption, showing that diesel fuel 2, angle of cover plate 75° and forward speed 2.51 km/hr recorded the lowest value fuel consumption 6.0 L/ha, whereas the highest value 20.5 L/ha at diesel fuel 1, angles of cover plate of 45° and forward speed 6.87 km/hr

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Table (4): Effect of study parameters on fuel consumption L/ha

Type of diesel fuel	Angle of cover plate	Forward speed km/hr			Type of fuel * Angle of cover plate	Type of fuel
		2.51	4.35	6.87		
Diesel fuel 1	45°	8.1 c	12.4 f	20.5 i	13.7 d	13.03 b
	60°	7.4 bc	11.7 ef	20.4 h	13.2 c	
	75°	7.2 b	10.6 e	18.8 gh	12.2 c	
Diesel fuel 2	45°	7.2 b	10.7 e	20.3 h	12.7 b	11.93 a
	60°	6.9 ab	9.8 d	18.4 g	11.7 b	
	75°	6.0 a	9.8 d	18.4 g	11.4 a	
Type of fuel * Forward speed	Diesel 1	7.6 b	11.5 d	19.9 f	Angle of cover plate	
	Diesel 2	6.7 a	10.1 c	19.3 e		
Angle of cover plate * Forward speed	45°	7.7 c	11.6 e	20.4 h	12.9 a	
	60°	7.2 b	10.8 de	19.4 g	12.2 a	
	75°	6.6 a	10.2 d	18.4 f	12.4 a	
Forward speed km/hr		7.2 a	10.9 b	19.4 c		

3.4 Effect of study parameters on productivity ha/hr

Data presented in table (5) indicated that there were significant differences between types of fuel diesel on productivity, when the highest value was 0.047 ha/hr with fuel diesel 2, whereas the lowest value 0.046 ha/hr with fuel diesel 1. But the angles of cover plate showed no significant effect on productivity, considering the impact of forward speeds on productivity, there was significant variance was observed between forward speeds, the speed of 6.87 km/h provided the highest productivity 0.067 ha/hr comparing with speed of 2.51 km/hr which obtained the lowest productivity 0.029 ha/hr, This cause due to the forward speed of tractor that considered main element to determine the productivity, also forward speed of tractor is directly proportional to the productivity, the result agreed with [19] and [20]. The collaboration between types of fuel diesel and forward speeds had significant differences on productivity, with the highest value of productivity 0.067 ha/hr with fuel diesel 2 and 6.87 km/hr of forward speed,

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whereas the lowest value of productivity was 0.028 ha/hr with fuel diesel 1 and 2.51 km/hr of forward speed. Concerning the interaction of angle of cover plate and forward speed the superior productivity of 0.067 ha/hr obtained at angle of cover plate of 75° and speed of 6.87 km/hr, whereas the lowest value 0.028 ha/hr at 45° of angle of cover plate and 2.51 km/hr of speed. Also with interaction between types of fuel diesel and angles of cover plate on productivity, the highest value was 0.048 ha/hr with fuel diesel 2 and angle of cover plate 75°, while the lowest value was 0.046 at fuel diesel 1 with 45° of angle of cover plate. Regarding the triple interaction between the factors, there were a significant influence among them and highest results were obtained from fuel diesel 2, angle of cover plate 75° and speed forward 6.87 km/h which got the highest value of productivity 0.068 ha/hr, whereas the lowest value of productivity was 0.028 ha/hr at fuel diesel1, angle of cover plate 45° and tractor speed 2.51 km/hr.

Table (5) : Effect of study parameters on productivity ha/hr

<table>
<tr><th rowspan="2">Type of diesel fuel</th><th rowspan="2">Angle of cover plate</th><th colspan="3">Forward speed km/hr</th><th rowspan="2">Type of fuel * Angle of cover plate</th><th rowspan="2">Type of fuel</th></tr>
<tr><th>2.51</th><th>4.35</th><th>6.87</th></tr>
<tr><td rowspan="3">Fuel diesel 1</td><td>45°</td><td>0.028 d</td><td>0.045 c</td><td>0.065 b</td><td>0.046 b</td><td rowspan="3">0.046 b</td></tr>
<tr><td>60°</td><td>0.029 d</td><td>0.045 c</td><td>0.065 b</td><td>0.046 b</td></tr>
<tr><td>75°</td><td>0.029 d</td><td>0.045 c</td><td>0.067 a</td><td>0.047 ab</td></tr>
<tr><td rowspan="3">Fuel diesel 2</td><td>45°</td><td>0.029 d</td><td>0.046 c</td><td>0.067 a</td><td>0.047 ab</td><td rowspan="3">0.047 a</td></tr>
<tr><td>60°</td><td>0.029 d</td><td>0.045 c</td><td>0.067 a</td><td>0.047 ab</td></tr>
<tr><td>75°</td><td>0.029 d</td><td>0.046 c</td><td>0.068 a</td><td>0.048 a</td></tr>
<tr><td rowspan="2">Type of fuel * Forward speed</td><td>Diesel 1</td><td>0.028 d</td><td>0.045 c</td><td>0.066 b</td><td colspan="2" rowspan="2">Angle of cover plate</td></tr>
<tr><td>Diesel 2</td><td>0.029 d</td><td>0.045 c</td><td>0.067 a</td></tr>
<tr><td rowspan="3">Angle of cover plate * Forward speed</td><td>45°</td><td>0.028 d</td><td>0.046 c</td><td>0.065 b</td><td colspan="2">0.047 a</td></tr>
<tr><td>60°</td><td>0.029 d</td><td>0.045 c</td><td>0.065 b</td><td colspan="2">0.047 a</td></tr>
<tr><td>75°</td><td>0.029 d</td><td>0.046 c</td><td>0.067 a</td><td colspan="2">0.047 a</td></tr>
<tr><td colspan="2">Forward speed km/hr</td><td>0.029 c</td><td>0.045 b</td><td>0.067 a</td><td colspan="2"></td></tr>
</table>

4 CONCLUSIONS

1) The forward speed of 2.51 km/hr gave lowest values for the fuel consumption, noise and slippage, which were of 97.9 dB, 7.2 L/hr, and 14.1% respectively.

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2) The diesel fuel 2, gave the lowest values for noise, fuel consumption, and slippage, which were 98.3 dB, 11.93 L/ha, and 14.4% respectively. While gave highest value for productivity 0.047 ha/hr.

3) The characteristics of noise, fuel consumption, and productivity were not significantly impacted by the angle of the cover plate.

4) The diesel fuel 2 and forward speed 2.51 km/hr gave lowest values of noise, fuel consumption and slippage which were 97.8 dB, 6.7 L/ha and 13.2% respectively.

5) The diesel fuel 2, angle of cover plate 75° and speed forward 2.51 km/hr recorded the lowest values for noise, slipping and fuel consumption 97.2 dB,13.3% and 6.0 L/ha respectively. While the same treatment gave highest productivity was 0.068 ha/hr.

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