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EFFECTS OF ENHANCER DIESEL FUEL AND VIBRATING WINGS SUBSOILER PLOW ON THE PERFORMANCE OF AN AGRICULTURAL TRACTOR

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Abstract

The aim of the study was to investigate the fuel consumption, depth stability ratio, noise, driver seat vibration of agricultural tractors (DSV), and slippage during tractor operation by using a kind of fuel (enhancer and non-enhancer fuel), vibration and non-vibration wings of subsoiler and engine speeds. Three engine speeds that include 1000, 1500 and 2000 rpm were considered. The results indicated significant positive data for all traits under enhancer fuel compared with non-enhancer and studies treatments. The experiment was analyzed as a three-factor factorial experiment using a split-split plot- Randomized Complete Block Design. Duncan's multiple range test used to test for significance. The results showed positive superiority of enhancer fuel in the fuel consumption, depth stability ratio, noise, DSV, and slippage, while achieving a negative increase in DSV, noise, and slippage with wing vibration of subsoiler. However, the DSV for wing vibration of subsoiler remained within European Parliament and Council Directive 2002/44/EC (OJ, 2002) and the measurements previously approved from ISO 2631-5 (2004). Besides, increasing the engine speeds leads to an increase in noise, DSV, and slippage, while at 2000 rpm speed of the engine was recorded as the lowest value of 11.905 L. ha-1 for fuel consumption, respectively. Finally, the results indicate the superiority of enhancer fuel and vibration wings at all engine tractor speeds to register less fuel consumption, DSV and slipping lead to the conclusion that adding enhancer fuel improved the performance of the agricultural tractor.

Keywords: Engine Speeds; Fuel Consumption; Noise, Vibrating Wings, Slippage.

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Introduction

During the COVID-19 pandemic, the Iraqi agricultural sector faced significant problems in overcoming the crop production gap and the high costs of farming operations (Al-Yasiri, et al .2021), in addition to other essential issues that followed the introduction of new farming, such as reduced tillage and no-till to reduce farm operating costs due to negative impacts on soils, including soil compaction and erosion (CSO,2019). Hardpan and soil compaction cause the reduction of soil water permeability and limit drainage. It also impacts the root zone, preventing it from expanding. (Odey and Manuwa,2018; Omori et al., 2020).

The wing vibratory subsoiler is one of the recent additions to Iraqi agricultural mechanization. It was previously only available in the experimental research sector, and its use did not spread until recently. Peasants in Iraq believe that vibratory subsoilers consume a lot of energy and that their usage is uneconomical; however, contemporary research in many nations has shown that vibratory subsoilers can be used successfully on a variety of soils (Hilal et al.,2021). Traditional soil tillage, compaction, and agricultural operations still practiced in large parts of Iraq are significant contributors to farm operating costs in Iraq, particularly in Mosul farms, where soil cultivation is carried out every season to deeply loosen the soil (Abdullah and Hilal, 2017).

Agricultural equipment performance is a substantial variable for machinery during the farming process, and it is inevitable for farm practices in agricultural mechanization management. Tractors are one of the power sources energized by equivalent energy and fuel for performance as a critical factor for effective parameters in tillage operations. The selection of fuel consumption and development performance for planting is one of the significant challenges farmers face. Further improvement of agricultural machinery performance and selected enhanced fuel to improve the tractor's performance is the key to agro-processing development and yield production in Iraq.

Enhanced diesel fuel additives protect the entire fuel system and improve corrosion protection. The additive increases the lubricating effect of the fuel, and cetane eases ignition, which leads to better combustion and makes it easier to start the engine. Mixing a proportion of the improvers with diesel to obtain the maximum percentage of the O2 content leads to an improvement in thermal efficiency and an apparent decrease in smoke opacity at high loads (Uyaroğlu and Ünaldi, 2021).

The noises and vibration of the driver’s seat of tractors directly affect the driver by degraded health and motion sickness, impaired activities, and reduced comfort. Zanganeh et al. (2021) reported that mechanical vibration causes health problems for drivers, such as back pain, spinal cord injury, etc. In this regard, when the engine is fully loaded, an increase in engine speed leads to a rise in vibration. The European Parliament has enacted minimum health and safety requirements regarding worker exposure to noise-related risks. It sets the average upper limit of worker noise exposure during an eight-hour work shift at 85 dB (European Commission, 2003; International Labor Organization, 2004). Factors that significantly influence the fuel consumption, depth stability ratio, noise, driver seat vibration of agricultural tractors (DSV), and slippage are engine speed, kind of fuel, ground unevenness, tillage equipment, and many other factors (Ghaderi et al.,2019; Tosun and Özcanlı,2021; Al-Rajabo et al.,2021). There are many fuel improvers in the local Iraqi and international markets. Until now, there is no study showing the credibility of these types so that the Iraqi farmer can choose the best style. Therefore, our research aims to investigate the effect of enhancer and non-enhancer fuel, wing vibration of subsoiler, and engine speeds on five characteristics that include the fuel consumption, depth stability ratio, noise, DSV, and slippage.

2. Materials and methods

2.1 Experiments Site

The field experiments were conducted on an experimental farm in agricultural and forest college, Mosul University, Nineveh province, Iraq. The farm is located within (E43,07'59.88 - N 36.23'08.26) "Longitude and al attitude as shown in Figure 1. The soil texture at the experimental sites was mainly clay; the field was not planted for eight years.

Figure (1) location of the experiment

2.2 Steps to implement the experiment

The subsoiler plow used in the study was a single tine with vibrated wings shaken by a crank mechanism driven by the tractor Power Take Of. The characteristics of the plow are working depth max. 60 cm and the overall width is 68 cm, with the width of the vibrating body being 35.8 cm—required tractor power 60 HP and machine weight 2549.729 N with Power Take Of shaft rotations 540 rpm. Experiment treatments included enhancer, and non-enhancer fuel, vibration and non-vibration wings, and three engine speeds of 1000, 1500, and 2000 rpm .

Diesel Smoke Stop from Liqui-Moly company that was used as an enhancer fuel. 150 ml of diesel smoke stop sufficient for 50 l of diesel fuel, i.e., 1:333. Pour the contents of the can directly into the tank before filling it up with fuel.

Depth Stability Ratio and fuel consumption were measured as described by Abdullah and Hilal (2017). DSV and noise of agricultural tractors (MF 75HP) were measured by Uni-TUT315A and Extech 407750 devices. The slippage of the tractor was calculated according to the equation by Janulevičius et al. (2018).

The experiment was factorial; it was conducted with three factors: non-wing and wing vibrations, engine speed, enhancer, and non-enhancer fuel, using Randomized Complete Block Design with Split –Split plot Design. The trial site was divided into 12 treatments with three replications for each treatment; the length of the treatment was 300 meters, with an affixed depth of 40-45 cm. Duncan's multiple range tests were used at the probability level of 0.05% and 0.01% to choose the significance of the differences between the mean of the different coefficients.

3- Results and Discussion

3.1 The impact of the kind of fuel on some field performance indicators

Table 1 shows the effect of the kind of fuel on the fuel consumption, depth stability ratio, noise, DSV, and slippage, respectively. The effect of the kind of fuel showed statistically significant differences in noise, DSV, and slippage. The field performance indicators recorded the highest considerable loss with non- enhancer fuel, negatively reflected in the efficiency of the tractor performance and equipment. The superiority of the enhancer fuel, with the lowest values of indicators over the non- enhancer fuel, is due to the improvement of the combustion quality and the increase in the efficiency of the agricultural tractor; meanwhile, an increase in combustion quality led to decreases the rate of fuel consumption, noise, DSV, and slippage, as presented in Table 1. The difference in the value between the enhancer and the non-enhancer fuel was 1.58 L. ha^{-1}, 0.347%,1.347 dB,1.164 $m.s^{-1}$, 2.452 % for the fuel consumption, depth stability ratio, noise, DSV, and slippage, respectively. These results are consistent with the theory that enhancer fuel's function significantly influences percentage losses (Sarıdemir and Ağbulut,2019; Jaikumar et al., 2019; Rajak et al., 2020).

Table (1): The impact of the kind of fuel on some field performance indicators

Kind of fuel	Fuel consumption L.ha-1	Depth stability ratio %	Noise dB	DSV m\s²	Slippage %
Non-enhancer fuel	14.046	87.430	A93.032	A4.733	A16.803
Enhancer fuel	12.466	87.777	B91.685	B 3.569	B14.351

3.2 The impact of the vibration and non-vibration wings of subsoiler plow on some field performance indicators

The fuel consumption, noise, and DSV showed a significant difference between the non-vibration and vibration wings in the tillage operation. The use of the vibration wings provided the lowest fuel consumption value and the increase in other field performance indicators, with values of 9.210L.ha-1, 87.396%,93.053 dB, 4.483 m.s-2, and 15.950 % of fuel consumption, depth stability ratio, noise, DSV, and slippage , respectively (Table 2).The reasons for the reducing fuel consumption of vibrating wings over non-vibrating wings were related to the fact that vibrating wings fracture the soil, reducing the soil cohesiveness in dry soils and leading to less draft and specific resistance. Moreover, the stress pulses are transmitted through the wet soil, resulting in a burst of hydrodynamic pressure and excess pore water pressure, reducing the effective stress and soil strength (Al-Rajabo et al., 2021). Despite the high value of DSV, it was within the permissible natural limits according to the international classification ISO 2631-5 (Dela Hoz-Torres et al.,2019).

The results show non-vibration superiority by producing low noise, slippage, and DSV of 91.664 dB, 15.200%, and 3.819 m.s-2 with a high production value for depth stability ratio was 87.813%. These results agree with (Hilal et al., 2021), who mentions that the vibration of the driver's seat increases with the increase in the vibration wings in the tillage operation.

Table (2): The impact of the vibration and non-vibration wings of subsoiler plow on some field performance indicators

Vibration wings of subsoiler	**Fuel consumption L.ha-1**	**Depth stability ratio %**	**Noise dB**	**DSV m\s^2**	**Slippage %**
Non-vibration wings	A17.302	87.813	B91.664	B 3.819	15.200
Vibration wings	B9.210	87.396	A93.053	A 4.483	15.953

3.3 The impact of engine speeds on some field performance indicators

The results showed that the effect of the engine speeds has statistically significant differences in the fuel consumption, depth stability ratio, noise, and slippage (Table 3). The noise, DSV, and slippage recorded the highest significant values with increased engine speeds; however, the value of fuel consumption decreases with increasing engine speed. An engine speed of 1000 rpm is superior in having the lowest noise, DSV, and slippage rate compared to an engine speed of 1500 or 2000 rpm. At the engine speed of 1500 (lower values), the depth stability ratio was 86.875%. In comparison, in the engine speed of 2000 (higher values), there were increased values, which were 95.093 dB, 5.229 m. s-2, and 20.868 % of noise, DSV, and slippage, respectively, as presented in Table 3. These results are consistent with (Seifi et al., 2016) that noise levels increase with increasing speed and the number of engine revolutions.

Table (3): The impact of engine speeds on some field performance indicators

Engine speeds	**Fuel consumption L.ha-1**	**Depth stability ratio %**	**Noise dB**	**DSV m\s^2**	**Slippage %**
1000	A14.895	88.229	C89.598	C 3.180	B11.830
1500	AB12.969	86.875	B92.383	B 4.044	B14.033
2000	B11.905	87.708	A95.093	A 5.229	A20.868

3.4 The impact interaction of the vibration and non-vibration wings of subsoiler and fuel kind on some field performance indicators

Table 4 shows statistically significant differences in the effect of the interaction between the vibration and non-vibration wings of subsoiler and fuel kind in noise and DSV. The enhancer fuel with both non-vibration and vibration wings showed the lowest values for field performance indicators, outperforming the non- enhancer fuel. The addition of the enhancer fuel led to a decrease in the fuel consumption, depth stability ratio, noise, DSV, and slippage for the non-vibration and vibration wings; for example, the results were 16.293 L.ha-1,87.639%,91.548dB,3.398 m.s-1 and 13.172% in enhancer fuel with non-vibration wings with 18.312 L.ha-1,87.986%,91.780 dB, 4.241 m.s-2, and 17.229% in non-enhancer fuel with non-vibration wings, respectively. The reason may be that the addition of fuel enhancers leads to an improvement in the combustion quality of the tractor engine, which leads to an increase in the efficiency of the tractor's performance.

The results showed significant superiority of the vibration wings over the non- vibration wings. The vibration wings were significantly better than the non- vibration wings, with fuel consumption of 9.780 and 8.640 L.ha-1 in enhancer and non- enhancer fuel, respectively. Furthermore, due to the efficiency and engineering design of the vibration wings, tillage was completed in a shorter time.

Table (4): The impact interaction of the vibration and non-vibration wings of subsoiler and fuel kind on some field performance indicators

Kind of fuel	**Vibration wings of subsoiler**	**Fuel consumption L.ha-1**	**Depth stability ratio %**	**Noise dB**	**DSV m\s²**	**Slippage %**
Non-enhancer fuel	**Non-vibration wings**	18.312	87.986	B91.780	B4.241	17.229
	Vibration wings	9.780	86.875	A94.284	A5.226	16.377
Enhancer fuel	**Non-vibration wings**	16.293	87.639	B91.548	C3.398	13.172
	Vibration wings	8.640	87.917	B91.822	C3.739	15.530

3.5 The impact interaction of kind of fuel and engine speeds on some field performance indicators

Table 5 shows statistically significant differences in the effect of the interaction between the kind of fuel and engine speeds in DSV. The noise, DSV, and slippage recorded the highest important values with increased engine speeds for both non-enhancer and enhancer fuel. The engine speed of 2000 rpm with enhancer fuel had the lowest fuel consumption value of 10.490 L. ha-1, while it had the highest depth stability ratio, noise, DSV, and slippage values. For example, it recorded 90.00 %,94.756 dB, 4.852 m. s-2 and 20.030% for depth stability ratio, noise, DSV, and slippage values, as presented in Table 5. However, the highest fuel consumption of 15.570 L. ha-1 was at an engine speed of 1000 rpm with non-enhancer fuel. It indicates that completing the tillage process using a low engine speed requires a longer time, which increases fuel consumption per unit area.

The results showed that the influence of enhancer fuel was different for each engine speed. The enhancer fuel outperformed the non-enhancer fuel with the lowest value of the fuel consumption, depth stability ratio, noise, DSV, and slippage; such as the noise and DSV values decreased from (90.494, 93.172 95.430) dB and (3.859, 4.734 and 5.607) m.s-2 to (88.702, 91.595 and 94.756) dB and (2.501, 3.353 and 4.852) m.s-2 when used enhancer fuel with an engine speed of 1000,1500 and 2000, respectively.

Table (5): The impact interactions of kind of fuel and engine speeds on some field performance indicators

Kind of fuel	**Engine speeds**	**Fuel consumption L.ha-1**	**Depth stability ratio %**	**Noise dB**	**DSV m\s²**	**Slippage %**
Non-enhancer fuel	**1000**	15.570	A 90.833	90.494	C 3.859	13.477
	1500	13.248	A 86.042	93.172	B 4.734	15.228
	2000	13.320	A 85.417	95.430	A 5.607	21.707
Enhancer fuel	**1000**	14.220	A 85.625	88.702	D 2.501	10.183
	1500	12.690	A 87.708	91.595	C 3.353	12.840
	2000	10.490	A 90.000	94.756	B 4.852	20.030

3.6 The impact interactions of the vibration and non-vibration wings of subsoiler and engine speeds on some field performance indicators

Fuel consumption, noise, and DSV were significantly affected by the vibration and non-vibration wings of subsoiler and engine speeds (Table 6). The field performance indicators were significantly different ($P < 0.05$) between the engine speed levels in vibration and non-vibration wings. In contrast, the values at vibration wings were considerably lower than that of non-vibration wings. The noise, DSV, and slippage recorded the highest important values with increased engine speeds; meanwhile, fuel consumption and depth stability ratio recorded the lowest values with increased engine speed for both vibration and non-vibration wings.

In contrast, the fuel consumption at level 1500 rpm of the engine speed was lower than that of the engine speeds 1000 and 2000 rpm, the fuel consumption was higher at level 1000 of the engine speed in non-vibration wings, while at the levels of engine speed 1000,1500 and 2000 rpm, there are no statistically significant differences concerning the percentage of threshing losses (Table 6). The noise and DSV were significantly higher at the engine speed of 2000, and a significant difference between 1000 and 1500 engine speeds on vibration and non-vibration wings.

Table (6) : The impact interactions of the vibration and non-vibration wings of subsoiler and engine speeds on some field performance indicators

Vibration wings of subsoiler	**Engine speeds**	**Fuel consumption L.ha-1**	**Depth stability ratio %**	**Noise dB**	**DSV m\s²**	**Slippage %**
Non-vibration wings	1000	A19.620	90.104	D 89.585	C 3.176	10.227
	1500	AB 17.658	87.083	C 91.464	C 3.727	14.961
	2000	B 14.630	86.250	B 93.943	B 4.555	20.415
Vibration wings	1000	C 10.170	86.354	D 89.612	C 3.185	13.433
	1500	C 8.280	86.667	B 93.303	B 4.360	13.107
	2000	C 9.180	89.167	A 96.244	A 5.903	21.322

3.7 The impact of three interactions between treatments on some field performance indicators

Table 7 shows the influence of the kind of fuel, vibration, and non-vibration wings of subsoiler and engine speeds on the harvest losses and harvester efficiency. The results indicated that values were influenced by the non-enhancer and enhancer fuel and the engine speeds in both vibration and non-vibration wings. The fuel consumption and depth stability ratio differed significantly ($P < 0.05$) between the treatments. The values at the enhancer fuel with both vibration and non-vibration wings at engine speeds were considerably lower than that of non-enhancer fuel with all treatments. Otherwise, the noise, DSV, and slippage were insignificant in all treatments. The results showed noise, DSV, and slippage was higher at engine speed 2000 in non-enhancer fuel with vibration wings. However, the depth stability ratio was significantly higher at an engine speed of 2000 rpm in enhancer fuel with vibration wings than that at an engine speed of 1000 rpm, and its highest value reached 94.167%, as a result of improved combustion by fuel enhancers, which leads to improved performance efficiency. At the same time, the engine speed of 1500 rpm in enhancer fuel with vibration wings recorded the lowest fuel consumption, which was 7.560 L.ha-1.

Table (7): The impact of three interactions between treatments on some field performance indicators

Kind of fuel	Vibration wings of subsoiler	Engine speeds	Fuel consumption L.ha-1	Depth stability ratio %	Noise dB	DSV m\s²	Slippage %
Non-enhancer fuel	Non-vibration wings	1000	A19.980	AB90.625	89.878	3.828	11.020
		1500	A17.496	AB86.667	91.489	4.113	17.972
		2000	A17.460	AB 86.667	93.972	4.780	22.697
	Vibration wings	1000	B11.160	AB91.042	91.110	3.891	15.933
		1500	B9.000	AB85.417	94.855	5.355	12.483
		2000	B9.180	AB84.167	96.888	6.434	20.717
Enhancer fuel	Non-vibration wings	1000	A19.260	AB89.583	89.292	2.524	9.433
		1500	A17.820	AB87.500	91.438	3.341	11.950
		2000	B11.800	AB85.833	93.913	4.331	18.133
	Vibration wings	1000	B9.180	B81.667	88.113	2.479	10.933
		1500	B7.560	AB87.917	91.752	3.365	13.730
		2000	B9.180	A94.167	95.599	5.373	21.927

CONCLUSION

The current study aimed to investigate the effect of enhancer and non-enhancer fuel, wing vibration of subsoiler, and engine speeds on five characteristics that include the fuel consumption, depth stability ratio, noise, DSV, and slippage. The data revealed that the best results were achieved with enhancer fuel in the fuel consumption, depth stability ratio, noise, DSV, and slippage while achieving a harmful increase in DSV, noise, and slippage with wing vibration of subsoiler. However, the DSV for wing vibration of the subsoiler remained within the internationally recognized standards. The engine speeds increase leads to an increase in noise, DSV, and slippage, while at 2000 rpm speed of the engine was recorded as the lowest value of 11.905 L. ha-1 for fuel consumption, respectively. It was observed that a non-enhancer fuel and non- vibration of wings negatively affect all of the traits. In addition, the depth stability ratio was significantly higher at an engine speed of 2000 rpm in enhancer fuel with vibration wings than that at an engine speed of 1000 rpm, and its highest value reached 94.167%, as a result of improved combustion by fuel enhancers, which leads to improved performance efficiency. A perfect setup of the tillage operation is the most crucial prerequisite for increasing the performance efficiency; therefore, it is recommended to expand the use of enhancer fuel by conducting more experiments and research in better conditions for Iraqi soil and yield production.

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