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Original article

Investigation of the Effects of Using Low Sulfur and Rural Diesel as Diesel Fuel in Tractors on Engine/emissions

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Abstract

Energy is one of the main factors that ensure the formation of production, development, and economic conditions between countries. Although fossil fuels pose some problems in terms of the environment and human health, they still have great use in meeting the energy demand in the world. Although there are many studies on alternative fuels in today's conditions, diesel engines are more preferred by the countries in heavy-duty vehicles (construction machines, tractors, and combine harvesters) operating in all kinds of commercial and land conditions that are used in transportation. Diesel engines are more preferred in developing countries due to their high torque and low fuel consumption. For this reason, efficiency, operating parameters, and reducing the environmental emissions of diesel engines used in our country are important. Since agriculture is one of the most important fields of activity in our country, in this study, the engine's characteristics and the effects on the exhaust emissions of the rural diesel used in the tractor and the low-sulfur diesel fuel were experimentally investigated. The maximum torque (1400rpm) used during the field plow of the tractor, which is available in Çerkezköy Hattat Tractor Factory R&D Center, and the maximum power (2100rpm) under other driving conditions were tested with both diesel fuels. When the results of the experiments were compared, it was seen that higher torque and power were obtained with the use of low sulfur diesel fuel, while harmful exhaust emissions were lower than rural diesel fuel. However, when the engine's fuel consumption is compared, it has been determined that rural diesel is consumed less than low sulfur diesel.

Keywords: Diesel engine, Energy, Power, Torque, Diesel fuel, Emissions.

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INTRODUCTION

Diesel engines are still used in motor vehicles produced, which are operating in commercial and agricultural fields in our country and in today's conditions. When the power values obtained from these engines and the exhaust's harmful emissions are examined, great developments have been achieved. Although many methods are used to reduce harmful exhaust emissions from internal combustion diesel engines, research on this subject still continues. Fuel properties used in diesel engines are one of the most important factors affecting combustion. The fuel used in internal combustion diesel engines affects the formation of combustion phases in the cylinder. As a result of this situation, the engine's characteristics (torque, power, and fuel consumption) and harmful emissions from the exhaust vary significantly. When the studies on the characteristic features of diesel engines and the reduction of harmful exhaust emissions resulting from combustion are examined in the literature,

In a study by Jaikumar et al. (2021) and in different research on reducing harmful exhaust emissions from diesel engines, the effects were investigated by adding Al2O3 (Aluminium oxide) nanoparticles to the existing B20 biodiesel. It has been observed that there are improvements in combustion characteristics and exhaust emissions with Al2O3 nanoparticles added to biodiesel at a rate of 50ppm. Hao et al. (2021) proposed a special fuel/air separation device (FSD) to improve combustion, optimization, and reduction of emissions in heavy-duty diesel engines. It has been observed that a better mixture is formed by increasing the air usage amount by dividing the fuel spray by the FSD device. As better combustion is achieved with the proposed FSD device, approximately a 6% increase in engine power and a significant reduction in harmful exhaust emissions have been achieved. Farias et al. (2021) investigated the change in the power produced by the engine and fuel consumption with some configurations made on-air and fuel flow in an agricultural tractor engine. With some applications on the turbocharger unit and intercooler, the fuel flow amount has been reduced by 10%, while the engine's power has increased by around 30%. Olum et al. (2019) investigated the effect of diesel at different temperatures used in agricultural tractors on engine performance and fuel consumption. It was observed that the power and torque of the engine increased by 1% - 3.49% by reducing the fuel temperature. In addition, fuel consumption decreased due to the decrease in the temperature of the diesel used in the tractor engine. The fact that the fuel temperature used in the tractors is at a constant value affects the performance and fuel consumption of the engine positively. For this reason, the seasonal temperature effect of atmospheric weather conditions will be prevented by keeping the diesel temperature constant. In a study in which Celikten (2008) added 10% ethanol to the diesel fuel used in a diesel engine, reductions in harmful exhaust emissions and smoke darkness were obtained. However, no benefit was obtained in engine torque and power. It has been observed that ethanol added to diesel fuel reduces harmful SO2 gas levels, especially from the exhaust. In addition, it is recommended to examine the changes in engine performance and emissions by changing the ethanol mixture ratio added to the diesel

fuel and injection pressure. Hazar et al. (2022) investigated the effects of adding safflower methyl ester to diesel oil at different rates and using it in a single-cylinder air-cooled diesel engine. In this study, it is stated that while carbon monoxide (CO) and hydrocarbons (HC) in exhaust emissions decrease, there are an increase in nitrogen oxide (NOx) levels. Gowthaman and Thangavel (2022) investigated the performance and emission behavior by adding coconut shell oil to the diesel fuel used in a diesel engine. By adding coconut shell oil to the diesel fuel, better combustion performance conditions were achieved in a single-cylinder direct injection diesel engine, and reductions in harmful exhaust emissions were obtained. Januleyicius et al. (2013) stated that the driving conditions of the tractors in the field conditions affect the fuel consumption and harmful emissions from the exhaust. In the study, which examines this change in the engine according to different load conditions, it is stated that the tractor consumes more fuel on unplowed lands and increases the harmful emissions from the exhaust. In a study by Kumar et al. (2013), it was stated that the additives of methanol, ethanol, and butanol, which are bio-alcohols added to diesel fuel, are effective in reducing harmful exhaust emissions from diesel fuels. It is also stated that the energy content of butanol added to diesel fuel is high, and it causes less wear in the cylinders. In the experimental study conducted by Demir et al. (2022), the effects of adding water, urea, and citric as additives to diesel fuel were investigated. Recently, selective catalytic reactor and AdBlue injection systems have been preferred to reduce NOx emissions due to emission limitations on diesel engines. For this reason, AdBlue is sprayed with a pilot injector to the exhaust manifold outlet to reduce emissions. It has been observed that these additives added to diesel fuel cause some power reduction as they worsen combustion and increase the specific fuel consumption, but provide significant benefits in reducing harmful exhaust emissions. Drazic et al. (2021) state that in terms of their effects on the environment, the use of biomass, biogas, and biomethane energies will reduce the greenhouse gas effect in the life cycle. In addition to all these, it has been stated that although different technologies are used to produce biogas as alternative energy to fossil fuels, improvements are still needed in terms of cost economy and sustainability.

In this study, unlike the literature, it is aimed to examine the changes that occur when rural and low sulfur diesel, which is sold as diesel fuel in our country, is used in tractors in today's conditions. The effects of each fuel on the engine performance values under the same conditions and the harmful emission levels emitted from the exhaust after combustion were investigated in this study.

MATERIALS and METHODS

Before starting the experiments, the engine was operated for 40 minutes and brought to the regime temperature. In the tests, the engine's power, torque, fuel consumption, and exhaust emissions were investigated at two different engine speeds by using low sulfur diesel and rural diesel as diesel fuel. The purpose of conducting the experiments in two separate cycles is to operate the tractor at a value close to the maximum torque speed in field conditions (driving in the field). In other words, the longest working

time in the field occurs at values close to 1400 rpm. After the tilling of the field, tractors are used at engine speeds close to maximum power at 2100rpm. The tractor in which these measurements were made and the emission measurement can be seen in Figure 1.

Figure 1. Test Tractor and Exhaust Emission Measurement

The dynamometer used in testing the characteristics (Power and Torque) of the engine used in the tractor experiments is shown in Figure 2.

Figure 2. Engine torque and power measurement dynamometer

Engine performance measurements were made with the Froment dynamometer from the tractor PTO, as seen in Figure 2. The experiments were repeated three times in a row, and the same results were obtained. The error rates of the measuring instruments used in the experiments are given in Table 1.

Table 1. Measuring equipment error rates

Measurement tool	Test equipment	Unit of measurement	Percentage
Torque Measurement	Froment 5	Nm	0.05
Power Measurement	Froment 5	kW	0.05
Fuel Consumption	Manuel	L/h	0.10
Emission Measurement	EcomJ2KN	ppm	0.02

The characteristics of the fuel used in the engine are given in Table 2. Two types of diesel fuel are used in today's conditions in Turkey. One of them is low-sulfur diesel and the other is rural diesel. Although many properties of both fuels taken from Tüpraş are the same, there is a big difference between the sulfur ratios. The use of fuels with high sulfur content causes many negative effects on both the engine and the environment in the long run. Low sulfur content is generally preferred in the automobile group and in engines where new-generation diesel engines are used. Rural diesel is still used in vehicles such as construction equipment, tractors, and combine harvesters with conventional diesel engines.

Table 2. Characteristics of the fuel (Sayin et al 2020)

Fuel properties	Tupras -408 Diesel	Tupras-404 Rural Diesel
Fuel density	820-845kg/m3	820-845kg/m3
Sulfur content	10mg/kg	11-1000mg/kg
Ash content	0.01(%)	0.01(%)
Cetane number	51	51

The technical specifications of the test engine used in the experiment are shown in Table 3.

Table 3. Engine data sheet (Perkins 2009)

Data sheet	**Properties**
Engine model	Perkins-1104D-44T
Number of Cylinders	4
Engine power	55kW
Engine Torque	241Nm
Compression ratio	18.1:1
Fuel pump model	Delphi Dp.310
Bore (mm)	105
Stroke(mm)	127

RESULTS and DISCUSSION

In the case of using rural and low sulfur diesel fuel in the test tractor, the torque change in the engine is shown in Figure 3. Maximum torque of 269.40Nm was achieved at 1400rpm with the use of low sulfur diesel. It is seen that it produces a lower torque value.

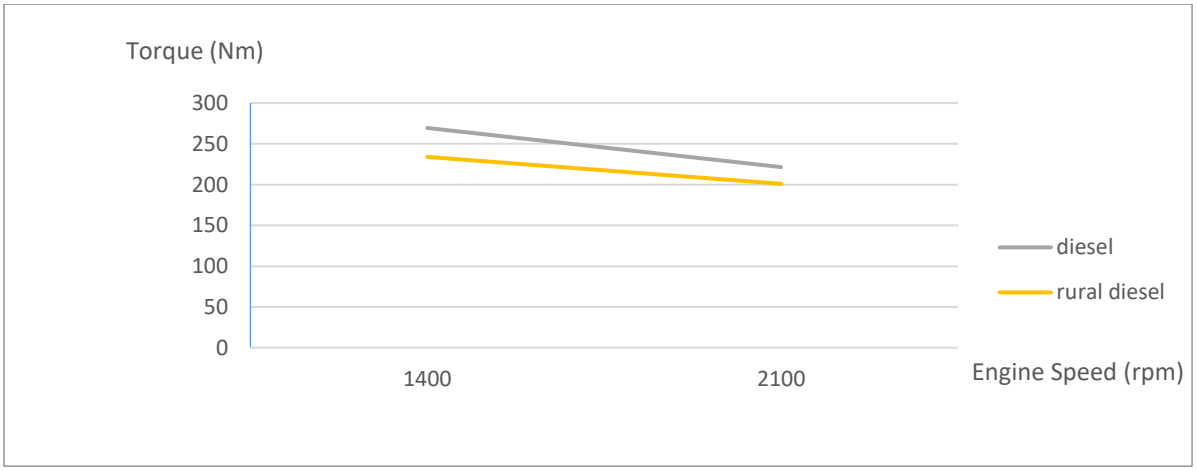

Figure 3. The torque variation in the engine

When the changes in the engine's power production are examined, more power is obtained by using low sulfur diesel oil. The maximum power of the engine in the Test Tractor is 2100rpm, and a power of 47.8kW was obtained at this speed. In the same conditions, 44.2kW power was obtained by using rural diesel fuel. The power change of the engine for both fuel types is shown in Figure 4.

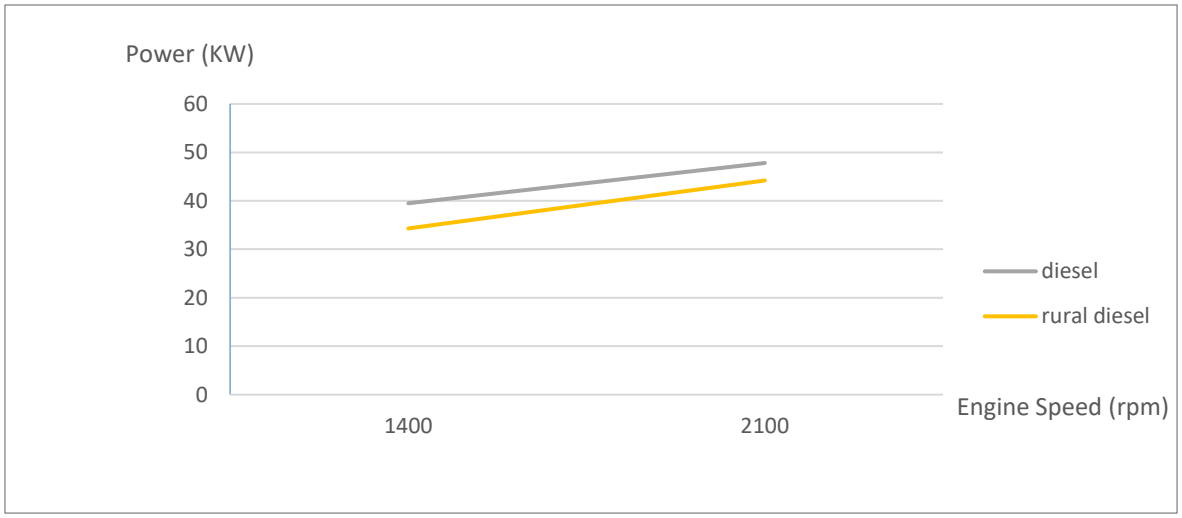

Figure 4. The power variation in the engine

If the tractor is used at maximum power and maximum torque, the fuel consumption in the existing engine is shown in Figure 5. Depending on the test results, it has been determined that the engine consumes less fuel using rural diesel.

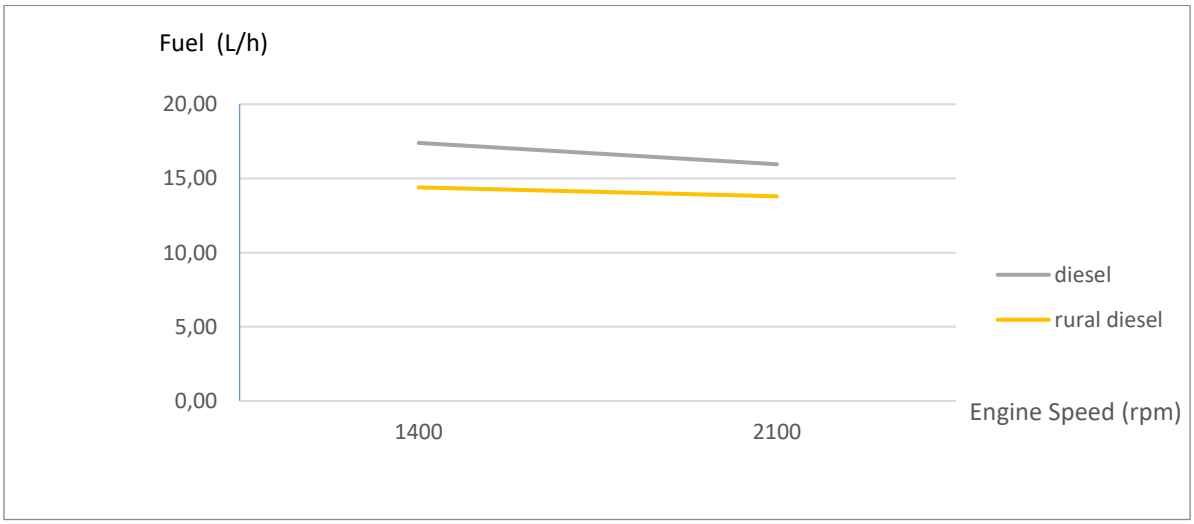

Figure 5. Fuel consumption

If low sulfur diesel is used as fuel in the tractor, the harmful emission levels emitted from the exhaust can be seen in Figure 6. According to the test results, it has been determined that the highest emission from the exhaust at 1400rpm is NOx (Nitrogen oxides) with a value of 361ppm.

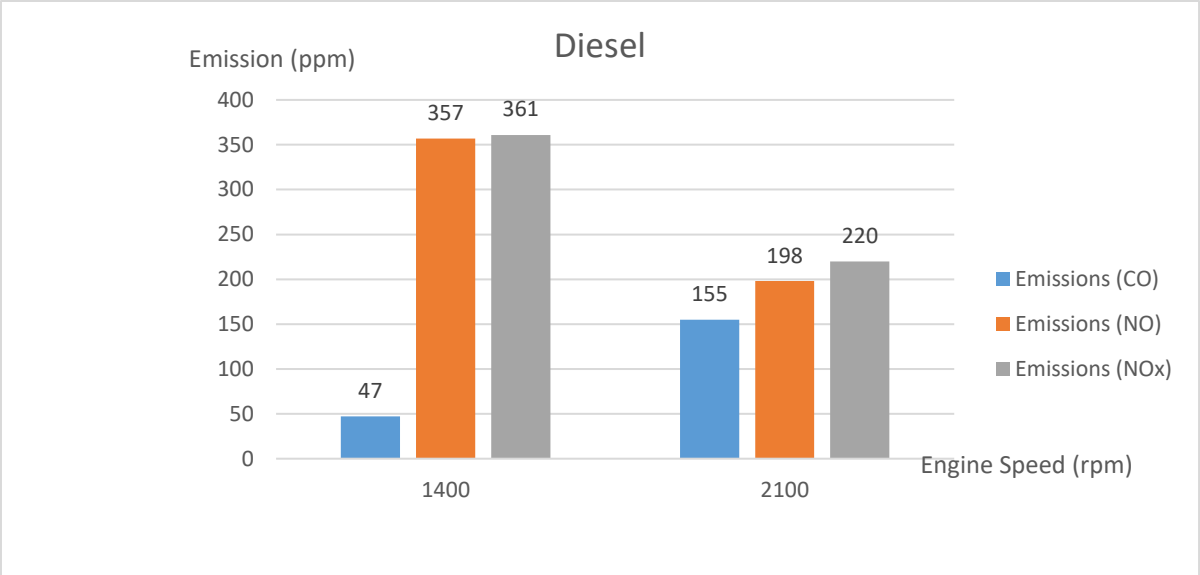

Figure 6. Diesel fuel emissions

If rural diesel fuel is used as fuel in the tractor, the harmful emission levels emitted from the exhaust can be seen in Figure 7. According to the test results, it has been determined that the highest emission from the exhaust at 1400rpm is NOx (Nitrogen oxides) with a value of 366ppm.

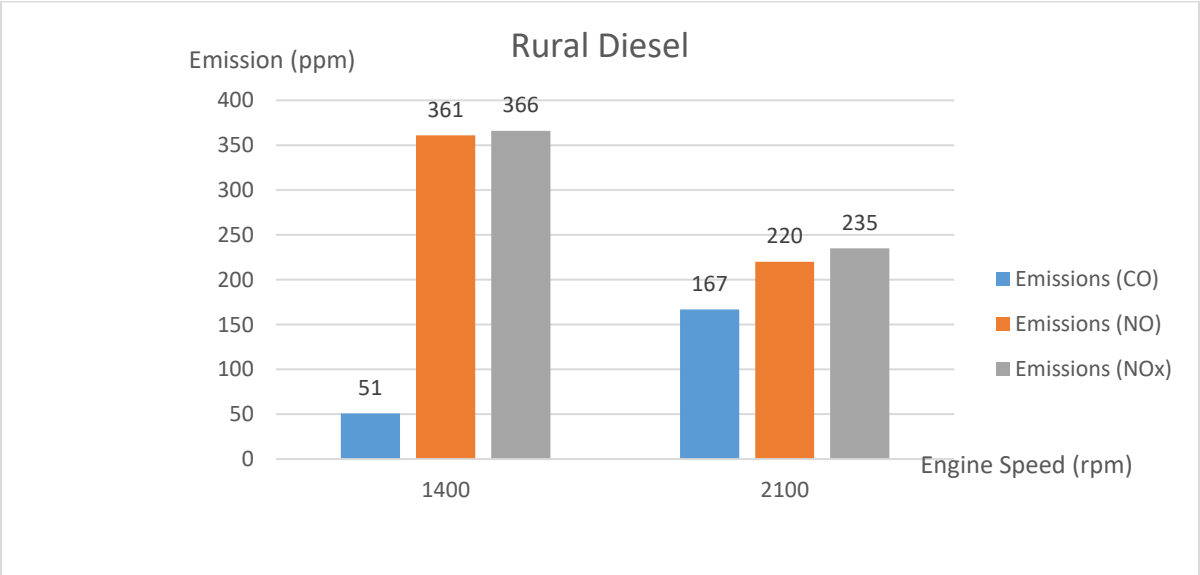

Figure 7. Rural diesel emissions

CONCLUSION

In this study, the effects of rural and low sulfur diesel fuel, which is sold as diesel fuel in our country in today's conditions, on the engine and the environment were investigated. The engine tests were carried out at 1400rpm, which is the maximum torque value at the time of driving in the field where the tractors are used the most, and at 2100rpm, which is the maximum power it is exposed to in off-field transportation. Depending on the test results, if low sulfur diesel is used in the existing tractor, it produces 36Nm more torque at 1400rpm, which is the maximum torque value of the engine. Similarly, 3.3kW more power is obtained at 2100rpm if low sulfur diesel is used. However, it has been observed that the engine's fuel consumption has decreased by about 3L/h in the use of rural diesel, especially at 1400rpm, which is the maximum torque speed. Although this seems to be an advantage in driving the fields away from settlements, other negative aspects should not be ignored. It has been observed that the harmful exhaust emissions released to the environment after combustion with the use of low sulfur diesel fuel are less in both cycles. This situation is important for the environment, humans, and other living things. In the future, it will be beneficial to test and compare rural diesel in different engines and to conduct studies to reduce these negative effects with some chemical additives.

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