

Fuel Consumption in Wheat Production in Irrigated and Dry Land Farming

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Abstract: Fuel consumption in wheat production was analyzed based on the operational fuel consumption for field machinery. This study was conducted over 17,833 hectares of irrigated wheat fields and 15,500 hectares of dry land wheat fields in Saveh city, Iran; in the harvest year of 2003-2004 (This study was part of a bigger study, Energy Consumption in Wheat Production in Irrigated and Dry Land Farming). The data was collected from three different sources: Questionnaire, literature review and field measurement. The maximum fuel consumed in wheat production, for irrigated farming systems, was about 598 L ha⁻¹ and 74 L ha⁻¹ for dry land farming, including irrigation and tillage, respectively. Fuel consumption in the production of one-kilogram of wheat, in irrigated farming and dry land farming systems, on average, was 0.20 L kg⁻¹ and 0.11 L kg⁻¹, respectively. Fuel consumption is an important input element, which must be measured under close managerial supervision, for precise, accurate amounts and methods, in order to decrease the amount of energy consumed.

Key words: Fuel consumption · production · agricultural machinery · wheat · operation inputs

INTRODUCTION

Saveh has a population of 275,000 over an area of 10,279 square kilometers, with an annual rainfall of 100 to 400 mm. The temperature varies from -20°C to 40°C [1]. Wheat is one of the major crops for feeding human beings. In 2003, Saveh contained a total of 150,000 hectares of arable land with 11% irrigated hectares in the wheat farming system and a total of 10% used for dry land farming.

Crop yields and food supplies to consumers are directly linked to energy and fuel; that is, sufficient energy and fuel is needed in the right form at the right time. Production agriculture includes all farming operations that occur after the land is cleared and developed, such as tillage, planting, fertilizing, pest control, harvesting, transportation and farm level drying or processing, up until the product leaves the farm. Energy needed for production agriculture is about 3% of the national energy consumption in developed countries and about 5 or 6% in developing countries [2]. The entire food system (food of a production, processing, storage, transportation and final operation) may require 15%, 20% or more of a developing nation's energy [3]. In recent years fuel costs have increased significantly and are predicted to dramatically increase in future. Consequently the price of agricultural production and food miles will be raised.

Fossil fuel energy can be either replaced with new sources of energy, or it can be optimized in an applied manner. One way to optimize energy consumption is to determine the efficiency of methods and techniques used [4]. There must be a plan for energy consumption; otherwise, with the current population increase, the world would come to a dead end. Energy consumption has been reduced in developed industrial countries from 4.9 to 1.3% within a 14 year period [5]. Use of diesel in tractors and diesel engines for doing various operations contributed 27.2% of the total energy input under irrigated conditions and electricity, which was used in irrigation only, supplied 12.7% energy [5]. The percentage of fuel of other energy resources is 70.7% and 48.4% in irrigated and dry land [1]. Therefore, one should recognize the input elements and prescribe a method for controlling them.

According to Siemens and Bowers [6] "depending on the type of fuel and the amount of time a tractor or machine is used, fuel and lubricant costs will usually represent at least 16 percent to over 45 percent of the total machine costs...". However the percentages of fuel and lubrication costs of the total costs in Iran because of subsidies are less than other countries. For example diesel and gasoline price were about only 0.02 and 0.1 US\$ in 2006, respectively; therefore, the reduction of fuel consumption is not very important for farmers. From 2007, new policies to step by step reduce fuel subsidies

were approved. It is predicted that these new policies will increase agricultural production expenditures significantly.

The objectives of this research were to determine the fuel consumption in wheat production based on field operations, in irrigated and dry land farming systems. 180 Irrigated farms and 100 dry land farms were selected randomly and information from each farm through face to face interviews was collected.

The fuel needed to produce one-kilogram of wheat in irrigated and dry land farming systems was determined. Field size and its effects on energy and fuel consumption were studied in detail in irrigated farms.

MATERIALS AND METHODS

Fuel consumption in wheat production operation such as tillage machinery, planters, fertilizer broadcasters, sprayers, irrigation, transportation and harvesting were determined in both farming systems, except for irrigation in dry land farming systems. The number and duration of operations were investigated by questionnaire and conducting personal interviews with farmers. Randomly selected farm owners completed the questionnaire. For each operation, fuel consumption was measured in the field by filling the tractor tank twice, before and after each operation and the difference recorded. From the literature review and ASAE standards [7], equivalent energy inputs were determined for all input and output parameters for wheat. For comparison of fuel consumption in different field sizes, irrigated farm land was surveyed based on three different size categories: less than two hectares, between two to ten hectares and land greater than 10 hectares. However, dry land was not divided into different categories due to extensive variations and having more fields of large sizes than irrigated land. Irrigation fuel consumption was included with water pumping from water surface to land surface (water well depths varied from 40 to 156 meters in the vast area of Saveh) and for surface irrigation.

Diesel fuel is the main source of fuel in agricultural machinery as well as motor pumps and water pumps, except in air spraying and portable sprayers. There are several methods to estimate the specific volumetric fuel consumption (SVFC) with a unit of L/kW_h (gal/hp_h) and SVFE with a unit of kW_h/L through using drawbar or PTO power (hp) of tractors. But most these methods are designed for specific areas and these are not useful for other areas because many factors such as height above sea level, air pressure, humidity, temperature, soil structure, tractor weight and etc are influence on tractor

Table 1: Fuel consumption in different operation (L ha⁻¹)

Operation	This study	CIGR
Moldboard plow	27±6	25±5
Disk	16±2	9±3
Grain drill	20±2	5±0.5
Fertilizer spreader	7±3	7±2
Sprayer	5	3±0.5
Leveler	15±3	-
Combine	25±2	18±2
Air spraying	2	-

power and fuel consumption. Furthermore, these equations are useful to predict fuel consumption for diesel engines during full and partial loads and under conditions when the engine speeds are reduced from full throttle [6]. For example according to the ASAE EP496.2, since most tractors tested and used for agricultural purposes in the last 25 years have had diesel engines, the above equations converted for diesel engines become:

$$Q_{avg} = 0.305 \times 0.73 \times P_{pto} = 0.223 \times P_{pto} \text{ (SI)} \quad (3)$$

$$Q_{avg} = 0.06 \times 0.73 \times P_{pto} = 0.044 \times P_{pto} \text{ (English)} \quad (4)$$

Q_{avg} = average gasoline consumption, L/h;

P_{pto} = maximum PTO power, kW;

These equations were used by Siemens and Bowers [6].

In this study for exact accurate, fuel consumption was determined before and after any operation by filling the tractor fuel tank and recording the difference. Different power and sizes of tractors were used for different operations and different farms. This test was repeated six times for each operation. Fuel consumption for wheat production was determined in this study and CIGR study [4] as shown in Table 1.

For self-propelled combines, the fuel was measured separately and was 25 ± 2 L ha⁻¹. Fuel consumption for air spraying was determined by fuel used in one year divided by the land areas in hectares, which was approximately 2 L ha⁻¹.

RESULTS AND DISCUSSION

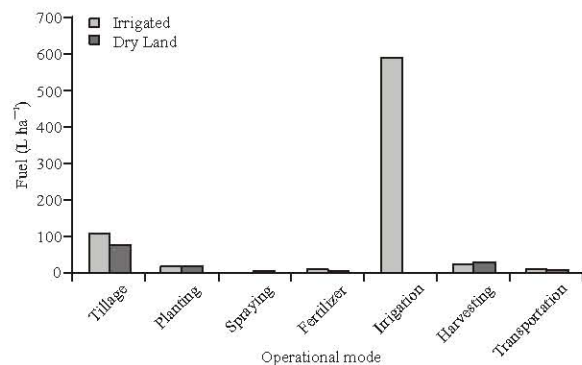
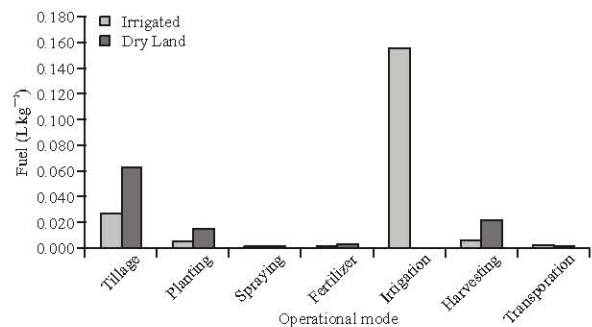
Fuel Consumption in Wheat Production for One Hectare of Land: Fuel consumption in wheat production operation includes: tillage, planting, fertilizer broadcasting, spraying, irrigation, transportation and harvesting; they were determined in irrigated farming systems as shown in Table 2 and Fig. 1. Except for irrigation, all other operations were considered for fuel

Table 2: Fuel consumption ($L ha^{-1}$) based on operations for wheat production

Acreage category (ha)	Tillage	Planting	Spraying	Fertilizer distributor	Harvesting	Irrigation	Transportation
Irrigation farming ($L ha^{-1}$)							
Less than 2	113.9	14.2	1.2	5.9	27.0	624.6	7.5
2 to 10	121.0	20.7	1.9	6.1	23.2	583.7	15.2
Greater than 10	101.0	19.1	1.8	6.6	20.1	593.3	5.7
Dry land farming ($L ha^{-1}$)							
Between 0.1 to 100	75.0	17.5	2.5	2.8	27.0	—	2.2

Table 3: Operational fuel consumption ($L kg^{-1}$) in the production of one kilogram of wheat

Acreage category (ha)	Tillage	Planting	Spraying	Fertilizer distributor	Harvesting	Irrigation	Transportation
Irrigation farming ($L ha^{-1}$)							
Less than 2	0.030	0.004	0.0003	0.002	0.007	0.16	0.002
2 to 10	0.028	0.005	0.0004	0.001	0.005	0.14	0.004
Greater than 10	0.028	0.005	0.0005	0.002	0.006	0.16	0.002
Dry land farming ($L ha^{-1}$)							
Between 0.1 to 100	0.062	0.015	0.002	0.002	0.02	—	0.002

Fig. 1: Operational fuel consumption ($L ha^{-1}$) in irrigated and dry land farming systemFig. 2: Operational fuel consumption ($L kg^{-1}$) in irrigated and dry land farming system

consumption of dry land farming system as shown in Table 2. The fuel consumption in wheat production per hectare was much higher in irrigated farming land than in dry land. It was around $755 L ha^{-1}$ and $127 L ha^{-1}$ for irrigated farming and dry land farming systems, respectively.

The operational fuel consumption was much higher in irrigated land due to tillage, fertilizer and irrigation operations; however, the major difference came from irrigation operations with 78.4% of total operational energy consumption. Operational fuel consumption in both systems is shown in Figure 2. Tillage is ranked high in systems. Tillage, operational fuel consumption, ranked first with 59% of dry land farming. Fuel consumption was not under any control by the farmers. They believed that more tillage can increase the yield. A serious educational workshop must be held about tillage and irrigation and methods for the farmer. The method of operation must

under studied and guidance given to managerial staff. Also, farmers have to learn; using several operations make environment impact such as erosion and soil compaction.

Operational fuel consumption was less for the large-scale farming systems than other categories, fuel consumption was $794 L ha^{-1}$ for less than two hectares field and $771 L ha^{-1}$ for farming between two and ten hectares, with $548 L ha^{-1}$ for greater than ten hectares. Therefore, larger field sizes should be practiced. Fuel consumption of transportation in farms between two and ten hectares is more than other categories. The survey shows in less than 2 hectare farms, most of the yields are produced for feeding and own consumption and in more than 10 hectare fields; farmers have used high efficiency methods for transportation. Furthermore silos were built close to bigger farms.

Table 4: Percentage of energy consumption, based on sources for irrigated and dry land farming system

Acreage category (ha)	Direct energy (%)			Indirect energy (%)		
	Human	Electricity	Fuel	Fertilizer	Pesticide	Seed
Irrigation farming (%)						
Less than 2	0.2	1.7	72.5	18.9	0.2	6.5
2 to 10	0.2	1.3	71.7	20.5	0.3	6.0
Greater than 10	0.3	1.2	70.3	22.2	0.3	5.7
Dry land farming (%)						
Between 0.1 to 100	0.1	--	48.4	37.7	0.7	13.1

Table1 shows fuel consumption in this study (Iran) and CIGR report (USA) and the difference in some operations happened for several reasons. Depreciation of equipment and tractors, inability to adjust the complex equipment, lack of coordination between equipment and tractors and between machines and size of farms and lack of appropriate education are important reasons for high fuel consumption in Iran. Furthermore, the average age of farmers (55 years) is more than the average age of society (24years) [1]; therefore their ability to new practice is reduced.

Fuel Consumption for One-kilogram of wheat

Production: Energy and fuel consumption for one kilogram of wheat production was determined as shown in Table 3 and 4 and Fig. 2 based on operations and sources for irrigated and dry land farming system. Based on operation, irrigation had the highest fuel consumption at 78.4% and as far as the source is concerned, the highest input was the fuel. The energy consumption for producing one –kilogram of wheat was much higher in irrigated farming land than in dry land. Tillage is ranked high in both systems. Tillage, operational fuel consumption, ranked first with 59%in dry land farming. Serious attention must be paid in order to control irrigation operation and tillage. Fuel consumption was 0.21; 0.18 and 0.20 L kg⁻¹ for land less than two hectares, between 2 to 10 hectares and greater than 10 hectares, respectively for irrigated farming system. On average, fuel consumption for irrigated and dry land farming system was 0.20 and 0.11 L kg⁻¹ as shown in Table 3.

Other results: As well as age, education is an important problem. This study showed about 8% of farmers are illiterate 45% of them can only read and write and they didn't finish primary school. Also, 40% of tractors drivers didn't take any workshops about their job.

On the other hand, the operational and economical age of many of tractors, equipment and combines was finished, for example the study shows the average age of tractors and combines are 16 and 14 years, respectively.

This research showed, most diesel water pumps were used more than 25 years as truck motor and motor pumps, consequently they did not work efficiently. Fortunately, in recent years, the government has encouraged farmers to use electrical pumps; therefore, the percentage of fuel and energy consumption in these farms has reduced to 70 and 30%, respectively.

CONCLUSIONS

Fuel input in wheat production in dry land systems is less than irrigated systems. Total average operational fuel consumed for grain production was about 37% higher than near east developing countries. Irrigation operation and tillage requires serious research and managerial attention to control the amount and methods to reduce the large expenses.

By far, in wheat production, fuel is the most important source of energy; and fertilizer comes second. A detailed study of amount and methods of fuel and fertilizer input must take place in order to reduce energy consumption. Using better water pumps and reduction of tillage methods can reduce fuel consumption significantly.

Efficient operation of farm tractors includes: (1) maximizing the fuel efficiency of the engine and mechanical efficiency of the drive train, (2) maximizing tractive advantage of the traction devices and (3) selecting an optimum travel speed and width for a given tractor implement system. Also, increasing the size of farms, improving the farmers' skills, improving operational methods and using better equipment and tractors can reduce fuel consumption effectively. Also it can decrease costs and environment impacts.

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