International Journal of
Agriculture, Environment and Food Sciences

JAEFS e-ISSN : 2618-5946 DOI: 10.31015/jaefs.2021.1.4 www.jaefs.com

Research Article Int J Agric Environ Food Sci 5 (1):23-32 (2021)

A research on the determination of energy consumption and carbon dioxide emissions in corn production in Harran plain

Nusret Mutlu[1,*]

[1]GAP Regional Development Administration, Sanlıurfa, Turkey

[*]Corresponding Author: nmutlu@gap.gov.tr

Abstract

Due to global climate change, greenhouse gas (GHG) analyzes for agricultural production systems are becoming more common with energy analyzes. In this study, carbon dioxide (CO_2) emissions in the Harran Plain due to fuel consumption in first crop seed corn production were evaluated. A total of 100 face-to-face surveys were conducted with a total of 100 producers in the Harran Plain and data were collected on fuel consumption in production processes. The calculations to determine the CO_2 emissions released as a result of corn production are based on the proposed method of calculation of the fuel-based CO_2 emissions in the Intergovernmental Panel on Climate Change (IPCC). The total fuel and oil consumption per unit production area (ha) for different field applications in corn production is 98 l/ha in the Harran Plain. The total fuel and oil consumption in unit production corresponds to 3645.89 MJ/ha of energy consumption, resulting in a total of 269.6 kg CO_2 emissions per hectare. The specific fuel consumption, the specific energy productivity, the specific CO_2 emission, the specific fuel efficiency, the specific energy consumption and the specific CO_2 efficiency in seed corn production in the Harran Plain were determined to be 8.91 l/t, 3.02 kg/MJ, 24.51 kg_{CO2}/t, 112.22 kg/l, 331.44 MJ/t and 40.80 kg/kgCO_2, respectively.

Keywords: Corn, Fuel consumption, Carbon dioxide emission, Harran Plain

Introduction

Due to its rich nutrients, corn is a very valuable product in terms of both human and animal nutrition and has a variety of uses. Corn is used both directly in human nutrition and as a raw material in starch, glucose, oil and feed industry. Corn demand is increasing in parallel with the development of animal husbandry in our country, depending on the feed demand. Corn grain is a very good source of energy, being rich in starch and high digestibility of starch increase the nutritional value. Corn is also an important roughage used in animal nutrition as green and as silage. In other words, most of the corn production is used as animal feed.

The efficiency and profitability of agricultural production depends on energy consumption. Today, agricultural production technologies are developing rapidly and aiming higher profitability. However, despite all efforts, exhaust emissions from the fuel and motor oil consumption of tractors and other agricultural machinery still exceed the permissible limits. The power and design features of agricultural tools and machines are not selected in accordance with the production processes and the operating conditions are not suitable due to the overloading of the engines, which have negative effects on the environment. In such cases, harmful substances, petroleum products and fumes in the exhaust emissions are released into the atmosphere. These emissions significantly damage natural ecosystems.

Cite this article as:
Mutlu, N. (2021). A research on the determination of energy consumption and carbon dioxide emissions in corn production in Harran plain. Int. J. Agric. Environ. Food Sci., 5(1), 23-32.
DOI: https://dx.doi.org/10.31015/jaefs.2021.1.4
ORCID: Nusret Mutlu: 0000-0002-5780-4152
Received: 26 October 2020 **Accepted:** 24 January 2021 **Published Online:** 12 February 2021
Year: 2021 **Volume:** 5 **Issue:** 1 (March) **Pages:** 23-32
Available online at : http://www.jaefs.com - http://dergipark.gov.tr/jaefs

Carbon dioxide (CO_2) comes first among the greenhouse gases and this effect is global. Some pollutants have local characteristics such as acid rains caused by SO_2 emission. Greenhouse gases are released through both natural processes and human activities. The most important natural greenhouse gas in the atmosphere is water vapor. However, human activities increase the atmospheric concentrations of these gases, causing large amounts of greenhouse gases to be released. This situation warms the climate by increasing the greenhouse effect.

The amount of irrigated land in the Şanlıurfa-Harran Plains, which has the most fertile lands of the Southeastern Anatolia Region, is around 142,000 hectares. It is inevitable for maize to take place in crop rotation systems in irrigated areas. Corn, which has a high yield potential in the region, is a plant that can be grown as a second crop after cool climate grains and lentils. Corn is an important field crop that should take part in a crop rotation with legumes, cool climate cereals and other cultivated plants in irrigated areas such as the Harran Plain (Kün 1992). With the implementation of the irrigation project in the Southeastern Anatolia Project (GAP) region, corn cultivation has come a long way over the years. With the full implementation of irrigation investments in the GAP, the plant and animal production pattern has naturally changed. In particular, the local sheep breeds with low yield potential have been replaced with high milk and reproductive fattening and high carcass quality cattle. In crop production, intensive agriculture was introduced with irrigation.

In a study conducted to determine the performances of 10 single hybrid maize varieties under the Harran Plain main and second crop conditions. It has been reported that there are statistical differences in the second crop conditions in terms of flowering time, plant height, cob height, thousand kernel weight, grain cob ratio and grain yield, and the grain yield varied between 682.8 and 966.8 kg/da (Dok 2005). Different researchers (Öktem 2005; Öktem and Öktem 2003; 2009; Coşkun et al 2011a; 2011b) reported that they obtained high grain yields in horse-tooth corn in the second crop conditions of the the Harran Plain. In a study by Çelik and Gülersoy (2013), the change in the agricultural product pattern of the Harran Plain with GAP was examined. There are important changes in the agricultural product pattern of the Harran Plain, which is studied with the help of remote sensing. More than 90% of the Harran Plain is class I lands and is ideal for agriculture. As a matter of fact, the agricultural product pattern of the Harran Plain, which started to be irrigated since 1995 with the GAP, has changed rapidly from dry agriculture to irrigated agriculture. The change in the agricultural product pattern of the Harran Plain was examined periodically and put forward with numerical values.

Unit area yield in seed corn has shown a rapid increase trend in recent years. The main factors in yield increase are the introduction of new varieties with high yield potential and further development of breeding techniques. In recent years, hybrid varieties developed by different commercial companies and research organizations are cultivated in the corn cultivation areas of our country, and the performances of each variety in different regions can also be different. In some studies conducted on this subject, Öktem and Öktem (2009) found that there were statistically significant differences in grain yield, grain moisture at harvest, plant height and first ear height between 26 grain maize genotypes that they examined for two years under Şanlıurfa second crop conditions. Coşkun et al. (2014) found that the yield performances of corn varieties differed in different growing years. Öner et al (2012) stated that the plant height, harvest moisture, stem diameter, number of rows in the cob, number of grains in the row, thousand kernel weight, grain/cob ratio and grain yield per unit area of corn genotypes included in different death groups are affected significantly depending on the locations and different death group. They also reported that its characteristics had a significant effect on 1000 grain weight, harvest moisture, grain yield per unit area, number of rows in the cob and the height of the first cob.

Çoşkun et al (2014) conducted experiments in 2008 and 2009 in order to examine the performance of some horse tooth corn varieties under second crop conditions in the Harran plain. In the experiments, 15 horse tooth corn varieties were used as herbal material. The experiments were carried out in a randomized block design with 4 replications. In the research; grain yield, flowering time, plant height, first cob height, grain moisture at harvest, grain / cob ratio were examined. The grain yield varied between 1173.75 (Rx770) and 1429.00 (ALPAGA) kg/da in 2008. The grain yield varied between 797.25 (ALINEA) and 1107.00 (DKC 6120) kg/da in 2009. Consequently, DKC 6120 variety can be recommended for the Harran Plain second crop conditions.

In this study, it was aimed to determine the total energy consumption (diesel+ motor oil) and CO_2 emissions in first crop seed corn production in the Harran Plain. For this purpose, the processes and fuel consumption in the production of seed corn in the Harran Plain were examined in detail. The diesel consumption values of the tools and machinery used in the production of seed corn were determined by surveys conducted with farmers. During the process of seed corn production, efficiency criteria for total fuel (Diesel + lubrication oil) consumption for the tractor engine in the use of equipment and machinery are defined based on production and consumption and CO_2 emission values. In this study, direct energy use and CO_2 emissions related to fuel and oil consumption in first crop corn production in the Harran Plain were evaluated. In the calculations made to determine the CO_2 emissions released as a result of corn production, the fuel-based CO_2 emission calculation method recommended in the Intergovernmental Panel on Climate Change (Anonymous 1996) was taken into consideration.

Material and Method

Material

Study area description

The region with the largest agricultural land and irrigation systems included in the GAP project is the Harran Plain. The Harran Plain is also having one of Turkey's most frequent irrigation systems with approximately 160 thousand hectares.

The Harran Plain (Figure 1) is surrounded by Şanlıurfa and Germiş Mountains in the north, Tek Tek Mountains in the east, Akçakale and Syria border in the south and Fatik Mountains in the west. The total area of the Harran Plain, which is 65 km in North-South direction, is approximately 225 thousand hectares. As the landforms of the Harran plain, it has a very high inclination in the North-South direction with a length of 50 km and a height of approximately 130 m. The slope values are even higher at the foothills of Tektek in the east of the plain and the Fatik Mountains in the west. This high slope creates a continuous flow of water in the North-South direction and from the mountains to the middle of the plain. While the said water flow increases in terms of drainage capacity for the northern regions of the plain, it decreases the groundwater level in approximately 15-20 thousand hectares of land close to the Syrian border and consisting of low altitude parts of the plain. Groundwater is in very deep parts in the north and approaches the soil surface around Harran and Akçakale in the South. In the South, this situation affects the yield of the plant as the groundwater rises up to the plant root zone and stays in the root zone.

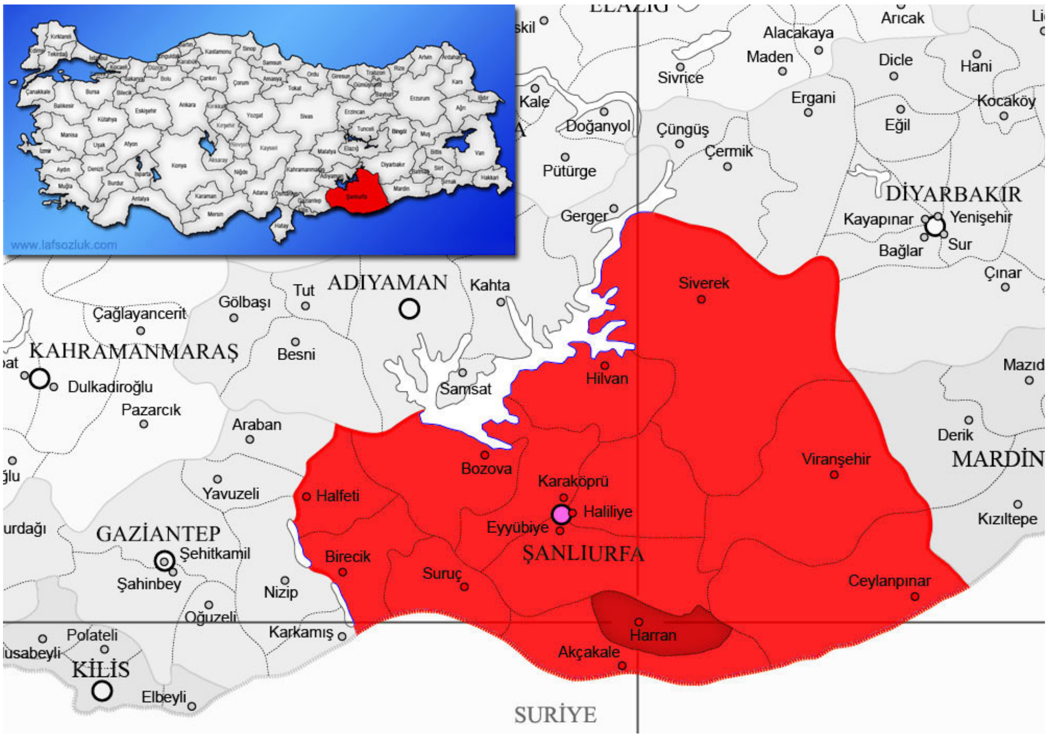

Figure 1. The map of the Harran Plain

A continental climate prevails in the Harran plain. The plain has a continental climate with not too cold winters and high temperatures in summer. Both daily and annual temperature differences are quite high. The climate data characterizing the Harran plain were evaluated using the data of Akçakale station. Temperatures generally show high values in the Harran plain. In the Harran plain, whose annual average temperature is 18 °C, the temperature values do not fall below 5 °C even in winter. In the summer, the temperature values are above 30 °C, showing a feature that almost resembles desert temperatures. Severe high temperatures in summer in the plain accelerate the salinization of agricultural lands. Salinization in the soil increases as high temperatures exacerbate the capillarity in the soil. In the study area, rainfall almost does not fall for about six months from May to October, and severe evaporation is observed in this period due to high temperatures (MGM 2020).

There are 6 different large soil groups in the agricultural areas of Şanlıurfa province. Among these, the ones covering large areas are red brown soils (1 236 366 ha), basaltic soils (431 218 ha), brown soils (167 325 ha). In addition, colluvial soils, brown forest soils and alluvial soils are included in the provincial agricultural areas. Harran series soils, which are widely included in the Harran Plain red brown soil group, are flat and nearly flat sloping soils with alluvial parent material. Typical red-colored profiles are clayey textured. Topsoil middle corner block, then granular; the subsoil is strong, large prismatic, then a strong middle corner block structure. It contains secondary lime pockets with increasing density towards the bottom (Dinç et al 1988).

Method

Method used to determine the sample size

The main material of the study is the primary data collected by making face-to-face surveys with seed corn producers in Harran Plain. In order to determine the number of questionnaires, the sampling size was calculated using the *Neyman* method (Yamane 1967) whose formula was given in equation (1).

$$n = \frac{(\sum N_h S_h)}{N^2 D^2 + \sum N_h S_h{}^2} \quad .....(1)$$

where: n- sample volume, d- projected deviation, N- total number of producers, z- standard normal distribution value, N_h = number of producers in the layer. S_h = layer variance and $D = d / z$.

The number of samples to be surveyed in the Harran Plain was determined with 5% deviation from the mean and 95% confidence level. In the Harran Plain (Figure 1); A face-to-face survey was conducted with a total of 100 corn producers and data on fuel consumption in production processes were collected.

Methods used in data analysis

Calculation of total fuel consumption

The diesel and engine oil values per unit production area (da) consumed by tractor during seed corn cultivation processes were evaluated as total fuel consumption.

$TFC=DC+LOC$……………(1)

Where; *TFC is* the total fuel consumption (l/ha), *DC* is Diesel consumption (l/ha) and *LOC* is the lubrication oil consumption (l/ha).

Calculation of lubricant oil consumption

The lubrication oil (lubricant) consumption per hour for tractor used in seed corn cultivation operations was determined as follows, depending on the tractor's highest power take off (PTO_{max}) (Öztürk 2010).

$LOC=0,00059xPTO_{max}+0.02169$……......(2)

Where; *LOC* is tractor lubrication oil consumption per hour (L/h) *and* PTO_{max} is tractor's highest *PTO* power (kW).

The maximum tail shaft power (PTO_{max}) for the agricultural tractor used for seed corn cultivation is taken into account as 88% of the tractor rated power (*TRP*, kW) and is determined as follows (Öztürk 2010).

$PTO_{max}=0.88xTRP$…………....(3)

Where; *TRP* is the rated power of tractor (kW).

Determination of total energy consumption

The total energy consumption (*TEC*, MJ/ha) pertaining to the consumption of diesel and engine oil per unit production area (da) was determined by the tractor used during seed corn cultivation processes are as follows.

$TEC=DEC+LEC$……………...(4)

Where; *DEC* is Diesel energy consumption (MJ/ha) *TEC* is the total energy consumption (MJ/ha) and *LEC* is the lubrication oil energy consumption (MJ/ha).

Calculation of Diesel energy consumption

The diesel energy consumption (*DEC*, MJ/ha) related to Diesel consumption consumed per unit production area (ha) by the tractor used during seed corn cultivation processes is determined as follows.

$DEC=DCxLHV_D$…………...(5)

Where; LHV_D is the lower Heating Value of Diesel (MJ/l).

The lower heating value of the Diesel (fuel) consumed by the tractor during agricultural production using agricultural tools and machinery was considered as 37.1 MJ/l (IPCC 1996).

Calculation of lubrication oil energy consumption

The lubrication oil energy consumption (*LEC*, MJ/ha) per unit production area (ha) consumed by tractor used during seed corn cultivation processes was determined as follows.

$LEC=LOCxLHV_L$…………...(6)

Where; LHV_L is the Lower Heating Value of lubrication oil (MJ/l).

The lower heating value of the lubrication oil (LHV_L) consumed by the tractor during the production operations in the field area with agricultural tools and machinery was taken into account as 38.2 MJ/L (IPCC 1996).

Calculation of CO_2 emissions

The CO_2 emissions from all motor vehicles burning fossil fuels can be calculated taking into account the amount of fuel consumed and the distance travelled. In the method of calculating CO_2 emissions taking into account the amount of fuel consumed, the value of fuel consumption is multiplied by the CO_2 emission factor for each type of fuel. This emission factor is developed depending on the thermal value of the fuel and the carbon fraction oxidized in the fuel and the carbon content. This approach is defined as the fuel-based CO_2 emission calculation method as it uses average fuel consumption data. The fuel consumption-based approach can be applied taking into account vehicle effectiveness data and fuel economy factors that enable the calculation of fuel consumption. Distance-based emission factors are taken into account when calculating emissions using the distance-based method. The fuel-based CO_2 emission calculation method is the preferred approach, since data on the fuel consumed is generally more reliable. However, since the uncertainty level in CO_2 estimates can be quite high, the distance based method should be used as a last remedy (IPCC 1996).

Fuel Heating Values and Selection of Emission Factors

Taking into consideration the lubrication oil consumption value of the tractor engine, CO_2 emissions related to oil consumption can also be calculated. The values given in Table 1 are used for the thermal values of diesel fuel and engine oil and CO_2 emission factors depending on the type of fuel.

Table 1. Thermal values and CO_2 emission factors (IPCC 1996)

Fuel	Lower heating value (MJ/l)	CO_2 emission factor ($kgCO_2$/MJ)
Diesel	37.1	0.07401
Lubricant oil	38.2	0.07328

Calculation of total CO_2 emissions

In calculating the CO_2 emissions released in result of seed corn production, the fuel-based CO_2 emission calculation method proposed in the Intergovernmental Panel on Climate Change was taken into account (IPCC 1996). The proposed approach to calculate CO_2 emissions based on fuel consumption is summarized in equations (8) and (9).

The total CO_2 emission (TCO_2E, $kgCO_2$/ha) pertaining to the consumption of Diesel and engine oil per unit production area (da) was determined by the tractor used during seed corn cultivation processes as follows.

$$TCO_2E = CO_2E_D + CO_2E_L \ldots\ldots\ldots\ldots(7)$$

Where; TCO_2E is the total CO_2 emission ($kgCO_2$/ha), CO_2E_D is the CO_2 emission related to Diesel consumption ($kgCO_2$/ha) and CO_2E_L is the CO_2 emission related to lubricant oil consumption ($kgCO_2$/ha).

Calculation of CO_2 emission related to Diesel consumption

The CO_2 emission (CO_2E_D, $kgCO_2$/ha) for Diesel consumption per unit production area (ha) was determined by the tractor used during seed corn cultivation processes as follows:

$$CO_2E_D = DC \text{x} LHV_D \text{x} EF_D \ldots\ldots\ldots\ldots(8)$$

Where; CO_2E_D is the CO_2 emission related to Diesel consumption ($kgCO_2$/ha), DC is Diesel consumption (l/ha), LHV_D is the Lower Heating Value of Diesel fuel (MJ/l) and EF_D is the CO_2 emission factor for Diesel fuel (0.07401 $kgCO_2$/MJ).

CO_2 emission calculation related to lubrication oil consumption

The CO_2 emission (CO_2E_L, $kgCO_2$/ha) related to engine oil consumption per unit production area (ha) was determined by the tractor used during seed corn cultivation processes as follows.

$$CO_2E_L = LOC \text{x} LHV_L \text{x} EF_L \ldots\ldots\ldots\ldots(9)$$

Where; CO_2E_L is the CO_2 emission related to lubrication oil consumption ($kgCO_2$/ha), LOC the lubrication oil consumption (l/ha), LHV_L is the Lower Heating Value of lubrication oil (38.2 MJ/l) and $EF_{L=}$ the CO_2 emission factor for lubrication oil (0.07401 $kgCO_2$/MJ)

The specific fuel consumption

The specific fuel consumption for the production of any product indicates how much fuel is consumed per unit amount produced and is defined by equation (10):

$$SFC = \frac{FC}{Y} = \frac{l/ha}{kg/ha} = \frac{l}{kg} \ldots\ldots\ldots\ldots(10)$$

Where; SFC is the specific fuel consumption (l/kg), FC is Amount of fuel consumed (l/ha) and Y is the amount of product produced (yield) (kg/ha).

The specific fuel efficiency

The specific fuel efficiency for the production of any product is the inverse of the specific fuel consumption value. It specifies how much product is produced per total amount of fuel consumed in production processes and is defined by equation (11):

$$SFE = \frac{Y}{FC} = \frac{kg/ha}{l/ha} = \frac{kg}{l} \ldots\ldots\ldots\ldots(11)$$

Where; SFE is the specific fuel efficiency (kg/l).

The specific CO_2 emission

The specific CO_2 emission indicates the CO_2 emission generated per unit mass of product produced during cultivation processes and is defined by equation (12):

$$SCE_{ems} = \frac{CO_2}{Y} = \frac{kg_{CO_2}/ha}{kg/ha} = \frac{kg_{CO_2}}{kg} \ldots\ldots(12)$$

Where; SCE_{ems} is the specific CO_2 emission (kg/kg_{CO2}).

The specific CO_2 efficiency

The specific CO_2 efficiency indicates the mass of product produced per unit CO_2 emission generated during cultivation processes and is defined by equation (13):

$$SCE_{eff} = \frac{Y}{CO_2} = \frac{kg/ha}{kg_{CO_2}/ha} = \frac{kg}{kg_{CO_2}} \ldots\ldots\ldots\ldots(13)$$

Where; SCE_{eff} is the specific CO_2 emission (kg/kg_{CO2}).

The specific energy consumption

The specific energy consumption related to fuel and oil consumption in the cultivation processes realized in the production of any product indicates how much energy is used per unit amount of the product obtained as a result of production and is defined by equation (14):

$$SEC = \frac{EC}{Y} = \frac{MJ/ha}{kg/ha} = \frac{MJ}{kg} \ldots\ldots\ldots(14)$$

Where; *SEC* is the specific energy consumption (MJ/kg) and *EC* is the amount of energy consumed (MJ/ha).

The specific energy efficiency

The specific energy efficiency (energy productivity) that occurs in the production of any product is the opposite of the specific energy consumption. It specifies how much product is produced per unit energy related to fuel and oil consumption in cultivation processes (Equation 15).

$$SEE = \frac{Y}{EC} = \frac{kg/ha}{MJ/ha} = \frac{kg}{MJ} \text{ .... (15)}$$

Where; *SEE* is the specific energy efficiency (kg/MJ).

Results and Discussion

Fuel consumption and CO_2 emissions

In the Harran plain, fuel and fuel energy consumption and CO_2 emission values per unit production area (ha) for different field applications in the production of first crop corn are given in Table 1. In the Harran Plain, 89.73 l diesel fuel is consumed per unit area (ha) in corn production. In response to the amount of fuel used at this value, a total of 3323.98 MJ of fuel energy is consumed per unit area (ha). Among corn production processes, the highest fuel consumption is in disc harrow and roller applications. In disc harrow and roller applications, 28.7 l fuel is consumed, which corresponds to 31.98% of the total fuel consumption. During soil cultivation at 15-20 cm depth with the plow, 18.8 l/ha fuel consumption is realized and this value corresponds to the energy consumption of 20.95% (697.48 MJ/ha) of the total fuel energy (Table 2). In terms of fuel energy consumption in corn production, the plow-soil process is followed by harvesting with corn headers (15 l/ha and 556.5 MJ/ha) and sowing (10.63 l/ha and 394.37 MJ/ha), respectively.

In the Harran Plain, the fuel consumption per unit production area and CO_2 emission values as a result of fuel consumption for different field applications in the production of first crop corn are given in Figure 2. A total of 246.38 kgCO_2 emissions are generated per unit production area (ha) in corn production. The highest amount of CO_2 emission occurs in plow deep plowing and disc harrow and slider applications, which are the two processes with the highest fuel consumption. The CO_2 emission per unit production area (ha) has been determined as 1064.77 kgCO_2 in disc harrow and roller applications and 697.48 kgCO_2 in plowing.

Table 2. Fuel and fuel energy consumption values per unit production area for different field applications in corn production

Cultivation processes	Fuel consumption per hectare (l/ha)	Total energy equivalent (MJ/ha)	CO_2 emission per hectare (kgCO_2/ha)	Ratio to total value (%)
Plowing	18.80	697.48	51.62	20.95
Discharrow and roller	28.70	1064.77	78.80	31.98
Sowing	10.63	394.373	29.19	11.85
Hoeing	4.20	155.82	11.53	4.68
Fertilizing	4.20	155.82	11.53	4.68
Spraying	8.20	304.22	22.52	9.14
Harvesting	15.00	556.5	41.19	16.72
Total	89.73	3328.98	246.38	100

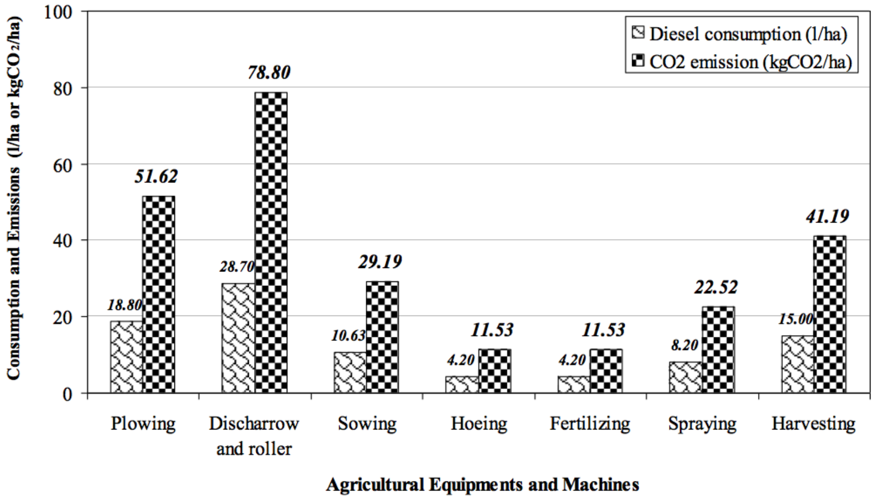

Figure 2. Fuel consumption and CO_2 emissions in corn cultivation processes

Oil consumption and CO_2 emission

Oil and fuel energy consumption and CO_2 emission values per unit production area (ha) for different field applications in corn production in the Harran Plain are given in Table 3. In the Harran Plain, a total of 8.3 liters of lubricating oil is consumed per unit area (ha) in corn production for tractors and combines used in seed corn harvesting. In response to the amount of oil used at this value, a total of 316.91 MJ of fuel energy is consumed per unit area (ha).

Table 3. Oil and oil energy consumption values per unit production area for different field applications in corn cultivation

Cultivation processes	Lubricant oil consumption per hectare (l/ha)	Total energy equivalent (MJ/ha)	CO_2 emission per hectare ($kgCO_2$/ha)
Plowing	1.578	60.28	4.42
Discharrow and roller	1.155	44.12	3.23
Sowing	0.968	36.98	2.71
Hoeing	0.685	26.17	1.92
Fertilizing	0.685	26.17	1.92
Spraying	0.725	27.70	2.03
Harvesting	2.5	95.50	7.00
Total	8.3	316.91	23.22

Among corn cultivation processes, the highest oil consumption (2.5 l/ha) occurs in the harvesting process. 1.578 l/ha of fuel consumption is achieved during tillage at 20-25 cm depth with plow (Table 3). In terms of oil energy consumption in seed corn production, plow soil treatment is followed by harrow and roller applications (1.155 l/ha and 44.12 MJ/ha), sowing (0.968 l/ha and 36.98 MJ/ha), spraying (0.725 l/ha and 27.70 MJ/ha), fertilization and hoeing applications (0.685 l/ha and 16.17 MJ/ha), respectively.

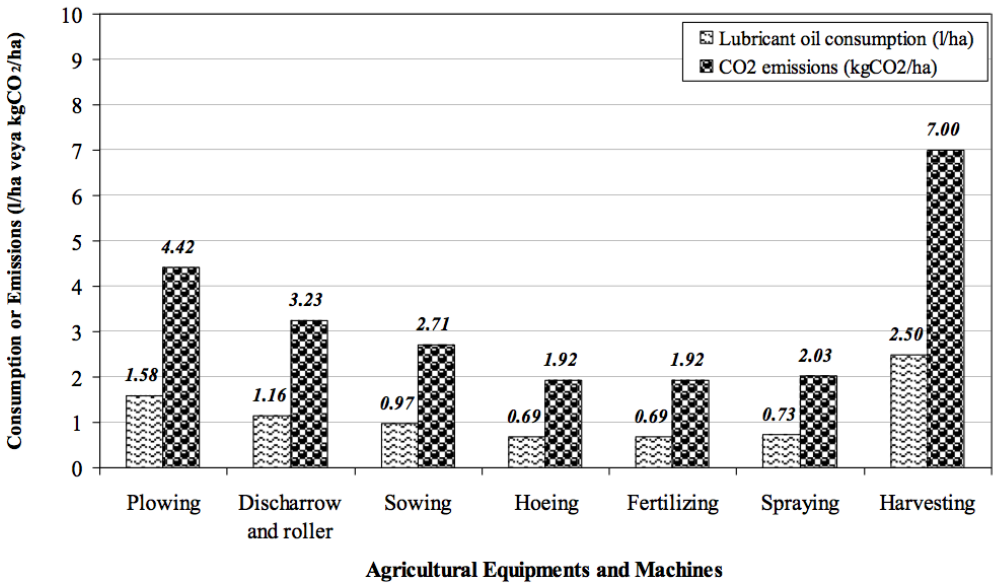

Figure 3. Oil consumption and CO_2 emissions in corn cultivation processes

In the Harran Plain, the lubricant oil consumption and the CO_2 emission values as a result of lubricant oil consumption per unit production area for different field applications in seed corn production are given in Figure 3. The total of 23.22 $kgCO_2$ emission per unit production area (ha) occurs as a result of oil consumption in corn production As with fuel consumption, the highest amount of CO_2 emissions occur in harvesting and plowing, which are the two processes with the highest oil consumption. The unit production area (ha) CO_2 emission realized as a result of engine oil consumption was determined as 7 $kgCO_2$ in the harvesting process and 4.42 $kgCO_2$ in the plowing process.

In the Harran Plain, 98 l total fuel and oil consumption per unit production area (ha) is realized for different field applications in seed corn production. The total fuel and oil consumption in the unit production area corresponds to 3645.89 MJ/ha energy use, resulting in a total of 269.6 $kgCO_2$ emissions per hectare.

The specific variables

Regarding fuel and oil consumption in different field applications in seed corn production in Harran Plain, the specific fuel consumption, the specific energy productivity and the specific CO_2 emissions are given in Table 4. The specific fuel consumption (l/kg) is defined as the ratio of the total amount of fuel consumed in the cultivation processes to the total amount of product harvested. The Specific fuel consumption refers to the amount (l) of fuel consumed to produce a unit quantity (kg or ton) of product. The low specific fuel consumption value means high energy efficiency in production. The specific fuel consumption in seed corn production in the Harran Plain is determined to be 8.91 l/t. In this case, respectively 8.91 l fuel is consumed for 1 t of seed corn production in the Harran Plain.

Table 4. The specific variables for fuel-energy-emission values in seed corn production

The specific variables	Seed yield (11000 kg/ha)
The specific fuel consumption (l/t)	8.91
The specific energy consumption (MJ/t)	331.44
The specific CO_2 emission ($kgCO_2$/t)	24.51
The specific fuel efficiency (kg/L)	112.22
The specific CO_2 efficiency (kg/$kgCO_2$)	40.80
The specific energy efficiency (kg/MJ)	3.02

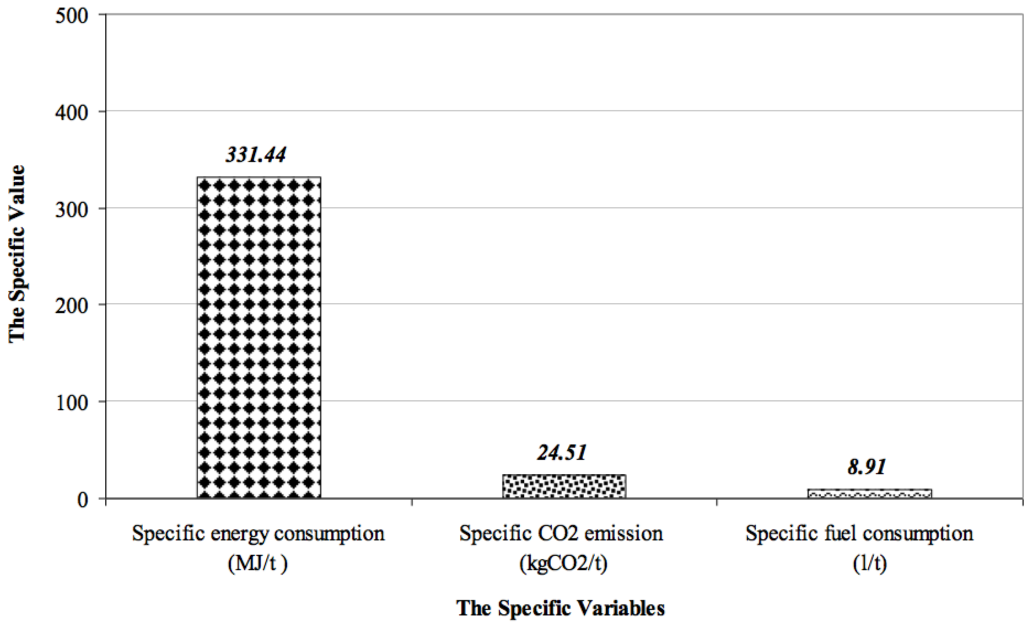

Figure 4. Change of specific variables in corn production

The specific fuel consumption

The specific energy consumption (MJ/kg) is defined as the ratio of the total amount of energy used for fuel consumption in cultivation processes to the total amount of crops harvested. The specific energy consumption value indicates the amount of energy (MJ) consumed in the cultivating processes to produce a unit quantity (kg or t) of product. The low specific energy consumption value means high energy efficiency and environmental efficiency in production. The specific energy consumption in seed corn production in the Harran Plain is determined as 331.44 MJ/t. In this case, 331.44 MJ of fossil fuel energy is consumed for 1 t seed corn production in the Harran Plain (Figure 4).

The specific CO_2 emission

The specific CO_2 emission ($kgCO_2$/kg) is defined as the ratio of CO2 emission realized as a result of the total amount of fuel consumed in cultivation processes to the total amount of harvested product. The specific CO_2 emission refers to the CO_2 emission ($kgCO_2$) value realized as a result of fuel consumption to produce a unit quantity (kg or t) of product. The low specific CO_2 emission value means that the energy efficiency in production is high and the negative effects on the environment are low. The specific CO_2 emission in seed corn production in the Harran Plain has been determined as 24.51 $kgCO_2$/kg. In this case, 24.51 $kgCO_2$ emission is realized for 1 ton seed corn production in the Harran Plain (Figure 4).

The specific fuel efficiency

Regarding the fuel and oil consumption in different field applications in the production of first crop corn in the Harran Plain, the specific fuel efficiency and the specific CO_2 efficiency values are given in Figure 5. The specific fuel yield (kg/l) is defined as the ratio of the total amount of product harvested to the total amount of fuel consumed in the cultivation processes. The specific fuel efficiency is the inverse of the specific fuel consumption (l/kg) value, indicating the amount of product (kg or t) harvested as a result of unit quantity (l) fuel consumption for cultivation processes. The high specific fuel efficiency value means that the energy efficiency of the production is high. The specific fuel efficiency in seed corn production in the Harran Plain has been determined as 112.22 kg/l. In this case, 112.22 kg of seed corn is produced in the Harran Plain as a result of 1 l fuel consumption for corn cultivation processes (Figure 5).

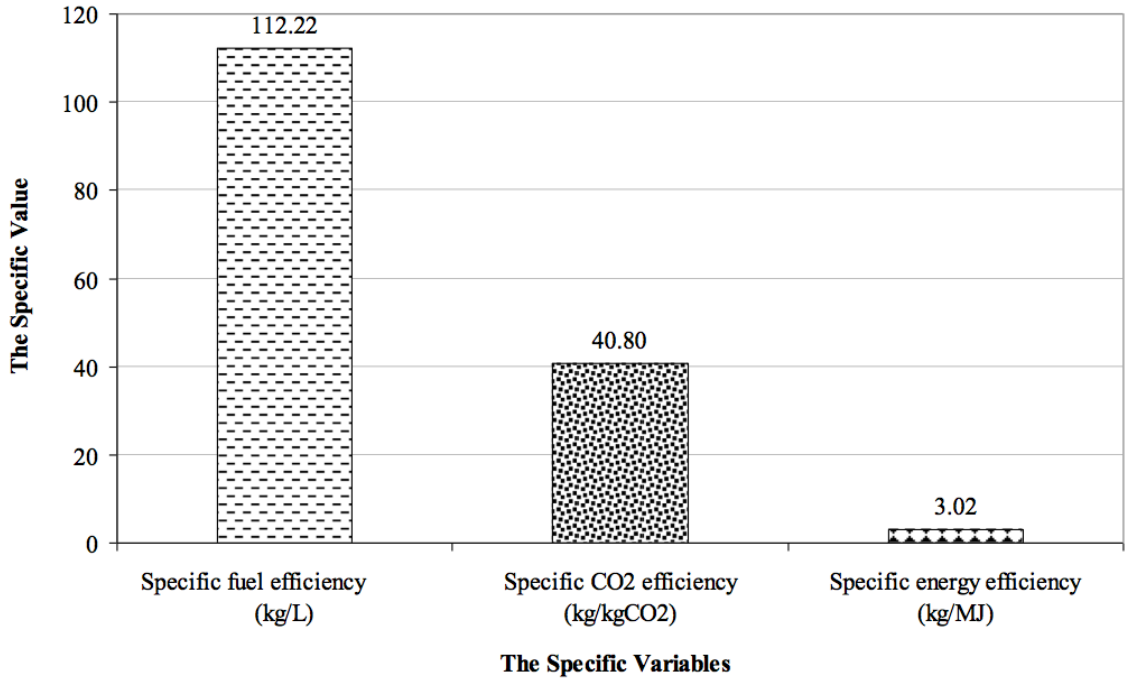

Figure 5. Change of specific variables in corn production

The specific energy efficiency

The specific energy efficiency (energy productivity) (kg/MJ) is defined as the ratio of the total amount of crop harvested to the total amount of energy used in the cultivation processes. The specific energy productivity refers to how much product (kg or t) is produced per unit amount of fuel energy (MJ) used. The high specific energy productivity value means the high energy efficiency in production. The specific energy efficiency in corn production in the Harran Plain has been determined as 3.02 kg/MJ. In this case, 3.02 kg of seed corn is produced in the Harran Plain as a result of 1 MJ of fossil fuel energy consumption for cultivation processes (Figure 5).

The specific CO_2 efficiency

The specific CO_2 efficiency (kg/kgCO_2) is defined as the ratio of the total amount of harvested product to the CO_2 emission realized as a result of the total amount of fuel consumed in the cultivation processes. The specific CO_2 efficiency value is the inverse of the specific CO_2 emission value and indicates the amount of product (kg or t) produced per unit CO_2 emission (kgCO_2) realized as a result of fuel consumption for cultivation processes. The low specific CO_2 efficiency value means that the energy efficiency in production is high and the negative effects on the environment are low. The specific CO_2 efficiency in seed corn production in the Harran Plain has been determined as 40.8 kg/kgCO_2. In this case, when 1 kg of CO_2 emission is relased as a result of fossil fuel consumption for cultivation processes in the Harran Plain, 40.8 kg of seed corn is produced (Figure 5).

Results and Conclusions

With the decrease in the agricultural population and labor force, mechanization practices have replaced human labor in production, and accordingly, production and productivity values have increased. The traditional tillage systems have been replaced by different tillage systems in recent years for various purposes such as reducing field traffic, minimizing production costs, and controlling erosion. Compared to traditional soil cultivation and protective soil cultivation, it requires higher inputs in terms of machinery investment, maintenance-repair and labor. As a result of researches, it has been determined that the conservative tillage and direct cultivation increase energy efficiency and reduce energy need. In cultivation with protective tillage, it is aimed to realize the production without disturbing the physical, chemical and biological structure of the soil with the least intervention to the soil. The conservative tillage planting is a planting system in which enough plant residues are left on the surface to protect the soil from erosion throughout the year. The direct sowing, zero tillage sowing, the reduced soil tillage sowing, mulch sowing, ridge sowing and permanent ridge sowing methods, which are alternative to the traditional soil tillage using plow, and with less intervention to the soil, are accepted as protective tillage sowing methods. Protective tillage production can be an alternative to the traditional tillage-cultivation system by ensuring the sustainability of agricultural production and efficient use of energy. Thus, ensuring the efficient use of all resources and converting them to the highest output is of great importance for agricultural and environmental sustainability. In addition, since chemical fertilizer applications, which constitute the most important energy input, are the most environmental pollutants, soil analysis should be done well and their applications should be used in accordance with the technique (especially by taking measures to reduce nitrogen fertilizers). Agricultural enterprises should analyze their current mechanization situation well and make their plans according to advanced technology levels. In particular, measures should be taken to reduce the power requirements and fuel consumption of the agricultural machinery used, and agricultural equipment and machinery should be used in accordance with the power source.

Compliance with Ethical Standards

Conflict of interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Author contribution

The author read and approved the final manuscript. The author verifies that the Text, Figures, and Tables are original and that they have not been published before.

Ethical approval

Not applicable.

Funding

No financial support was received for this study.

Data availability

Not applicable.

Consent for publication

Not applicable.

References

Coşkun, A., Coşkun, Y., Yıldırım, A., Koşar, İ. (2011a.). Adaptation of Some Horse Tooth Maize Genotypes to Second Crop Conditions of Harran Plain. GAP VI. Agriculture Congress, 09-12 May, Şanlıurfa, S. 595-600.

Coşkun, A., Coşkun, Y., Kara, O. (2011b). Investigation of Yield and Yield Related Characteristics of Some Horse-tooth Maize Varieties under Second Crop Conditions in the Harran Plain. GAP VI. Agriculture Congress, 09-12 May, Şanlıurfa, S. 601-606.

Coşkun, Y., Coşkun, A., Koşar, İ. (2014). Adaptation of Some Horse Tooth Corn Varieties to Second Crop Conditions in Harran Plain. Turkish Agriculture and Nature Science Journal 1 (4): 454-461.

Çelik, M.A., Gülersoy, A.E. (2013). Remote Sensing Investigation of the Changes Caused by the Southeastern Anatolia Project (GAP) in the Agricultural Structure of the Harran plain. International Social Research Journal Volume: 6 Issue: 28 S: 1307-9581.

Dinç, U., Şenol, S., Sayın, M., Thompson, DS, Sobeih, W., Rodriguez, G. (1988). Southeastern Anatolia Soils (GAT) 1. Harran Plain, TÜBİTAK Agriculture and Forestry Research Project No: TOAG - 433, Adana.

Dok, M. (2005). Research on Yield and Yield Components of Some Corn Varieties in Main and Second Crop Corn Cultivation in Harran Plain. GAP IV. Agriculture Congress, September 21-23, Şanlıurfa, pp 861-866.

IPCC, (1996). Climate Change, 1995: The Science of Climate Change. Contribution of Working Group I to the Second Assessment Report of the Intergovernmental Panel on Climate Change [Houghton., J.T., et al. (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 572 pp.

Kün, E. (1992). Grain and Legume Production. TÜBİTAK Science and Technical Journal 25 (292): 25-27.

MGM, (2020). Meteorlogy General Directorate, Ankara.

Öktem, A. Öktem, A. G. (2003). Adaptation of Some Maize (*Zea mays* L.) Genotypes to the Harran Plain Conditions. Turkey 5th Field Crops Congress, October 13-17, Diyarbakir, S. 212-222.

Öktem, A.G. (2005). Determination of Grain Yield and Cob Characteristics of Some Horse-tooth Maize (Zea mays L. indentata) Genotypes Grown under the Harran Plain Conditions. GAP IV. Agriculture Congress, September 21-23, Şanlıurfa, pp. 1526-1533.

Öktem, A., Öktem, A.G. (2009). Determination of Performances of Some Horse-tooth Maize (Zea mays L. indentata) Genotypes under the Harran Plain Conditions. Harran University Faculty of Agriculture Journal 13 (2): 49-58.

Öner, F., Sezer, İ., Güler, A. (2012). Comparison of Horse-tooth Corn (Zea mays L. indendata) Varieties and Lines Grown in Different Locations in terms of Agronomic Characteristics. Tekirdağ Agriculture Faculty Journal 9 (2): 1-6.

Öztürk, H. H. (2010). Energy Management in Agricultural Production. Hasat Publishing. Istanbul.

Yamane, T. (1967). Elementary Sampling Theory. N.J., USA. Prentice Hall Englewood Cliffs.