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Some Operating Parameters, Energy Efficiency, Carbon Dioxide Emission and Economic Analysis of Triticale and Wheat Grown in High Altitude Semi-Arid Climate Conditions

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ABSTRACT

Triticale is an important plant in animal nutrition that can be used to close the considerable gap in roughage and concentrated feed in our country. Furthermore, with the developments in recent years it has become possible for triticale to be used as a mixture in the production of human foods as well as used alone. In this study, some operating values, energy usage efficiency, CO_2 emission and gross profit of Umranhanım triticale, which was produced in 2014-2015 and 2016 under rain fed agricultural conditions and registered by East Anatolian Agricultural Research Institute. In addition, comparisons have been made over the same parameters with Doğu-88 wheat which has been grown by our Institute during the same years and conditions as well as registered by our Institute. Accordingly, the highest average fuel consumption in agricultural tools and machinery used in triticale and wheat production was the plow (20.59 l ha^{-1}) followed by the cultivator and harvester. The highest energy input with 43.32% was fertilizer energy, followed by fossil source diesel fuel-oil input with a 41.6% decrease. It has been determined that triticale produced 41.8% more energy than wheat plants and 0.8 MJ energy was consumed to produce 1 kg of triticale while wheat required 77% more energy. A similar situation occurred in energy productivity, 1.2 kg triticale was produced with 1 MJ energy while the amount of wheat produced was 0.7 kg. 33.2% more gross profit was achieved in triticale production compared to wheat.

***Keywords*:** triticale, wheat, fuel consumption, energy efficiency, CO_2 emission, economic analysis

Introduction

Triticale is an amphidiploid of wheat and rye hybrid and an artificial cool climate cereal type resistant to cold, drought and diseases (Kaydan and Yağmur 2008). The first significant development regarding triticale was obtained with the hybridization of wheat and rye by Wilson in 1875 (Varughese et al. 1987). The first studies on triticale in our country were initiated with materials provided by CIMMYT in the 1970s. Production permission was obtained for the Bakırçay variety, however the first type of triticale was registered by Bahri Dağdaş International Winter Grain Research Center (Konya) in 1997 under the name of Tatlıcak 97 (Kutlu and Kınacı 2011).

When the data for the past 10 years is evaluated it shows that the world's triticale cultivation areas have increased by 28% to 4.2 million hectares in 2016 from approximately 3.2 million ha in 2002 (FAOSTAT 2018). Among the main countries growing triticale in the world Poland has the highest cultivation area with 1 403 519 ha, followed by Germany with 396 100 ha and France with 334220 ha. When China, Russia, Spain, Hungary and Lithuania are included in this group, 73% of the world's triticale cultivation is carried out by these countries. Turkey started to grow triticale in 2003 and constitutes 0.9% of triticale cultivated in the world with 37621 ha as of 2016.

Triticale, which can be used in arid conditions more efficiently than other cool climate grains, gets resistance to diseases from rye plants and can be grown in areas instead of wheat in areas where wheat production is restricted. (Genç et al. 1988). It is reported that triticale has better ability to utilize soil than grains such as wheat, barley and oats, and is therefore less affected by changing environmental conditions. (Gregory 1974). In fact, triticale is cultivated in acidic soils, high altitudes and stony areas (Barier et al. 1980).

Compared to wheat, it has an economic and environmental advantage with lower input requirements. It is resistant to diseases to a major degree and has high efficiency in low-yielding soils. Because of these properties, it is the most suitable grain plant for the organic farming system (Hackett and Burke 2004).

Wheat is one of the most produced crop plants in the world and is an indispensable cultivar in terms of nutrition, trade and crop rotation systems in many countries. The cultivation areas and production of wheat, which has no alternative in terms of human nutrition, is increasing in parallel with population growth. It is estimated that the per capita wheat consumption in the world was approximately 70 kg in the 1960s and it is now around 100 kg. Average world wheat yield increased to 300 kg da^{-1} in recent years, and as of 2010, the world wheat yield record has been determined as 1564 kg da^{-1}. Turkey can produce about 1/5 of the potential of the existing cultivation areas. Accordingly, the opportunity to increase wheat production by increasing the unit area yield without increasing the existing cultivation areas continues (Anonymous 2011).

Wheat production which was approximately 2.5 million tons in our country in the 1930s increased to 10 million tons in 1967 and to 20.6 million tons in 2009. The wheat production increase rate was 724% during this period. While this increase in production up to a certain period incurred because of the increase in cultivation areas, in the subsequent period improvement works and suitable cultivation techniques made a significant contribution to the increase in production. The yield obtained from a unit area was 92 kg da^{-1} in 1930 and increased by 35.9% in 1967 to 125 kg kg da^{-1}. While the increase in cultivation areas from 1967 to 2010 was 1.0%, the increase in yield was realized as 104.8%. Turkey's population was approximately 13.6 million in 1927 and reached 73.7 million as of 2010. According to this, the rate of increase in the population from 1930 to 2010 was 442%, while the rate of increase in wheat production was 724% which has prevented major bottlenecks in our country in terms of countering the demand for wheat (Anonymous 2011).

The average yield of triticale (376348 da) in Turkey is 332 kg^{-1}, while in the North East Anatolian region (18255 da) yield has decreased by 13.3% to total 288 kg^{-1} and the yield in Erzurum (3804) has decreased by 8.7% to total 303 kg da^{-1} (TUİK 2016).

Fischer (1993) reports that Triticale has a high protein content and a good amino acid balance, which is a better feed quality than wheat and barley.

Triticale is an alternative product for marginal areas and is more resistant to the stress conditions caused by the environment than wheat and barley. Significant improvements in summer and winter yields have been achieved over the years and it has been used as plants or grain to feed cattle and sheep, especially poultry. Because of its poor grinding and cooking qualities the use of Triticale in human food used to be limited, however as a result of the developments achieved in recent years, it can now be used alone as well as mixed with quality wheat flour in different proportions and used in baking cakes, biscuits, bread and making pasta (Bağcı et al. 1999).

Giunta and Motzo (2005) explained that the reason why triticale has a higher yield grain potential than wheat was because of the number of grains per unit area, grain weight and growth rate of each grain and a longer grain filling time.

The average plant height, spike lengths, grain number-yield and unit area yields of wheat, barley and 4 different varieties of triticale were examined in a study carried out under the conditions of Van and the highest values were determined in triticale (87.8cm, 7.8cm, 41.5 units^{-1} 38 g and 303.5 kg da^{-1} respectively) (Yağmur and Kaydan 2007).

The grain yield, dry grass and green grass yield for triticale, bread wheat, durum wheat, rye and oat genotypes in terms of adaptation status has been revealed in a study conducted in the Thrace region. All of the triticale genotypes studied were higher in yield, green grass, and dry grass than durum wheat, barley and oat varieties and the majority showed higher value and adaptation than bread wheat and rye (Başer et al. 2008).

The widespread use of machinery in agriculture, the related increase in the use of inputs and the industrial consumption habits that came with the urbanization has reduced the importance of barley, oats and rye. The world's triticale production area has increased by 99% in the last 20 years (2016) while production has increased 92%. The triticale production area in our country has increased by 27% from 2004 to 2016 while production increased 32% (FAOSTAT 2018).

For sustainable economic development, greenhouse gas emissions need to be on a minimal level. Between 1970 and 2004, CO_2 emissions from fossil fuel use increased by around 80% and global temperature increased by 0.5°C (Nazlı 2017). The agricultural sector contributes significantly to global energy use and greenhouse gas emissions. More agricultural production will be needed to feed the growing world population. Therefore, the negative effects of agriculture on the environment will increase. 9% of the greenhouse gas emissions in 2014 were generated by agricultural production procedures by the agricultural sector throughout the world (Öztürk et al. 2017).

Agricultural land use and vegetation changes account for about 20% of global CO_2 emissions per year. A significant portion of the CO_2 emissions from agricultural activity can be reduced by conservation and reduced agricultural production processes (IPCC 2011).

Frequent droughts, extreme and unexpected rainfall have deteriorated the agricultural systems and balances of many countries to significantly affect their crop production. In addition to these changes in ecology, the increasing world population has caused the resources to decrease rapidly. This has led to a necessity to incur a steady increase especially in the production of cereals as well as the necessity to produce in marginal areas, which has led researchers to identify new product groups and increase unit yields. The first successful study on this issue has been obtained in triticale (Kün 1996).

This study was carried out for 3 years on a high elevation plain in a rain fed semi-arid climate zone with wheat which is the most widely produced plant in the world with no alternative in terms of human nutrition and triticale which is important in animal nutrition and has been used in human nutrition in recent years grown simultaneously and under the same field conditions. Some work achievements, fuel consumption, human labour requirements, energy inputs and fuel-based CO_2 emissions and gross profits of triticale-fallow and wheat-fallow planting executed by traditional method (moldboard plow + cultivator + Combined harrows + sowing + harvesting machine) have been determined and the differences in the values for both plants have been manifested.

Materials and Methods

Trial area

The study was carried out in the trial areas of the Eastern Anatolia Agricultural Research Institute, which is located at an altitude of 1721 m in the Erzurum-Pasinler plain of the Eastern Anatolia Region. The principal soil groups in the trial areas with a flat topographic structure are alluvial and colluvial soil groups . The study region has a semi-arid climate, the summers are short, the winters are cold and snowy. The long year average (2000-2016) of total annual precipitation is 423.5 mm while the average temperature is 6.1°C and average relative humidity is 66.9%.

Agricultural applications

The same equipment was used in soil tillage, sowing, maintenance and harvesting processes (Figure 1) in triticale and wheat production and their properties are given in Table 1. All equipment was towed with a 50 kW tractor with a weight of 3 396 kg and an economic life of 12000 hours. In practice, the parcels were driven at a depth of about 25-30 cm by means of a two-casing reversible mouldboard plow as the primary tillage tool. Subsequently a cultivator which was the secondary tillage tool was used at a depth of 12-15 cm as well as rotating disc harrow was used for seed bed preparation. The seeds of triticale and wheat were sown with a disk harrow with a capacity of 5-6 km h^{-1} in the second week of September with 200 kg per unit area (ha).

Before the planting both plants, chemical analyzes of soil samples taken from the trial areas were carried out and according to the results of the analysis, triple super phosphate (42-45% P_2O_5) ammonium nitrate (33% N) and Urea (46% N) were applied in varying doses.

Operation values

Time measurements of the agricultural tools and machines used in the trial were taken with 1/100 C min double-tap timepiece with the total time study and work phases added time method for actual speed; tractor-mounted speed radar and skidding sensors mounted on the tractor wheel at an angle of 120°. Actual fuel consumption was measured by using; The fuel was measured using a specially designed electronic fuel counter with a precision of 1% placed between the fuel tank and the pistons and between the pump and the fuel tank for recycles (Figure 2). Measured data were converted to significant data in the data storage unit and evaluated according to equations recommended by Özden (1995) and the ZET computer package program.

Energy efficiency

Table 2 shows the energy equivalents of inputs (diesel fuel-oil, human labour, tractor and instrument-machine manufacturing energy, chemical fertilizer, seed) and outputs (yield) to calculate energy output/input values in triticale and wheat production.

The energy efficiency use for triticale and wheat production (soil tillage, sowing, maintenance and harvesting) has been calculated with the help of the equations proposed by Öztürk (2010) as the output/input ratio, specific energy, energy efficiency and net energy efficiency depending on the energy inputs and outputs. Energy inputs are evaluated as direct and indirect in terms of energy usage, and as renewable and non-renewable in terms of energy resources. While human labour, diesel fuel-oil energy was considered as direct energy, machine manufacturing, seed, chemical fertilizer, agricultural drug energy inputs were taken as indirect energy. (Lorzadeh et al. 2011).

Carbon Dioxide Emission

Fuel-based CO_2 and specific carbon dioxide emissions have been calculated by taking into account the fossil fuel and oil consumptions used during the 3 years of triticale and wheat production based on rain fed conventional crop rotation conditions at a high altitude and semi-arid climate zone (Öztürk et al. 2017).

Gross margin analysis

Gross margin analysis for wheat and triticale production was carried out according to Aras 1988. Gross margin was calculated by subtracting the variable costs from the gross production value. Furthermore, variable expense rate and production threshold (yield-price) were calculated with the following formulas in order to compare the results of the production of triticale and wheat.

Results and Discussion

Fuel consumption and operational values

It has been determined in this study that the effective business success and fuel consumption, human and machine labour need values can be correlated with operating parameters. Accordingly, considering the production period of triticale and wheat, negative linear correlations have been determined between the average work performance and fuel consumption (r=0.737), human labour requirement (r=0.759) and machine labour requirement (r=0.719). Similar results have been reported by Leghari et al. (2016) that effective work performance has a negative association with fuel consumption.

The agricultural tools and machinery used in both plant productions were the same and the obtained values which were close to each other were analysed by means of averages. According to this, using 38.2% of the total diesel fuel (20.6 l ha^{-1}) in agricultural equipment used in both plants, the highest CO_2 emissions (59.1 kg CO_2 ha^{-1}), human labour (4.1 h ha^{-1}), machine use (3.8 h ha^{-1}) was obtained from the plow that correspondingly processed the least amount of area (0.264 ha h^{-1}) in the time unit (h). This was followed by the cultivator (19.4 l ha^{-1}) which consumed 49.4% less fuel than the plow. The lowest fuel consumption and fuel based CO_2 emissions on the basis of the agricultural equipment used were determined to be the pulveriser which consumed 94.3% less than the plough (Table 3). In their study Gözübüyük et al. (2001-2011) indicated that they had obtained similar results with traditional soil tillage-planting applications in terms of fuel consumption and some operating parameters.

In the study, an average of 0.11 hectares of land (tillage, sowing, maintenance and harvesting) and 12.7 h of human labor were needed for the tillage, sowing, maintenance and harvesting of triticale and wheat. In addition to the 53.9 liters of diesel fuel consumption, 154.7 kg of CO_2 was released into the atmosphere. 11.57 g CO_2 specific CO_2 emissions were generated for the production of one unit (kg) of triticale, while wheat produced under the same conditions was found to generate 43.3% more specific CO_2 emissions (Table 4).

Grain and straw yields

The three-year average yield of 3.92 kg ha^{-1} for triticale in Erzurum was above the average for Turkey (3:03 to 3:32 ton ha^{-1}) (TSI 2016) which is 26.6% more when compared to the wheat yield (Figure 3). A similar situation was manifested in the straw yield, 33% more straw was obtained from triticale (9.62 ton ha^{-1}) than the wheat plant.

Input-output energy requirements in triticale and wheat

In terms of energy inputs of wheat plants and triticale, the energy input for wheat was 63.7% higher for agricultural pesticide inputs (273 MJ ha^{-1}), 53.3% higher for fertilizer input (6417 MJ ha^{-1}) and 3.5% higher in seed input (2696 MJ ha^{-1}) while in other energy inputs (fuel-oil, human labour and machine manufacturing) wheat had an average of 2.1% less energy input compared to triticale (Figure 4). Chemical fertilizer used for both plants according to the results of soil analysis was the leading and highest energy input followed by fuel-oil and seed input while the lowest input consisted of the human labour input. The rate of input of fertilizer energy in the distribution rates of inputs was 38.4% for triticale, while this rate was 48.3% for wheat (Figure 5). While the wheat fertilizer energy input in this study almost equalled the Turkey average (48.8%) it was more than the rate obtained in a study conducted in the U.S. (21%) (Yaldız et al. 1990; Kumar et al. 2013). The seed input energy in the study was above the average in Turkey with 23.9-20.3% (15.1%) while in developed countries the average was around 7% (Yaldız et al. 1990; Anonymous 1989). The value obtained for tool-machine manufacturing energy input rate at 8.1-6.4% was close to the average in Turkey (6.7%) amounted to half the value for the U.S.A. (Yaldız et al. 1990). While 115028 MJ energy output was obtained for the Triticale plant per unit area in return for an energy input of 10905 MJ, the corresponding output for wheat was 22% more in input and 29% less in energy output (Figure 6).

Energy efficiencies

The main purpose of agricultural production is to obtain optimum yield with minimum cost or to use energy efficiently. The energy ratio, which means the energy efficiency in production which is desired to be high was 10.5 for the triticale plant and 41.8% lower for the wheat plant. In order to produce one unit quantity (kg) of product, 0.8 MJ energy was used for triticale while 77% more (1.4 MJ) energy was used for wheat. In the production of triticale, 1.2 kg of product was obtained for the unit of energy consumed (MJ) while the amount of product from the wheat plant was 43.5% (0.7 kg) less. The triticale from the unit area (ha) generated a net energy output of 104123 MJ, while the net energy output of wheat was less by 34.3% (Figure 7).

Direct (25.6%) and renewable (22.3%) energy inputs on plant basis were found to be quite low In the study, compared to indirect (74.4%) and non-renewable (77.7%) energy inputs (Figure 8). Although better values are obtained from triticale than wheat, it is not proportionally on the desired level. It has been determined that both plants generate mostly limited non-renewable energy inputs which are harmful to the environment are predominant and they are caused by high fertilizer and diesel fuel-oil energy input.

Gross margin

The variable costs per hectare in wheat production amounted to 1148.2 lira, while in triticale production amounted to 1045.7 lira (Table 5). The cost structures of both products are similar and 30.4% of the variable costs in wheat production was fertilizer, 27.9% was seed and 24.1% was fuel costs, while in triticale production 33.6% of the expenses were fertilizer, 26.5% was fuel and 23.9% were seed costs.

While the market prices of products and by-products were close to each other, there were significant differences in terms of yield. In the unit area (ha) wheat had a kernel yield of 2875.2 while triticale yielded 3916.7 kilograms and the by-product yield of wheat was 6444.9 while triticale yielded 9618.3 kilograms. This significant difference in yield is reflected in gross production value and gross profit. In wheat production, the gross profit per hectare is 4604.4 lire while this is 6896.8 lira for triticale production. When the two products are compared proportionally, the variable costs in wheat production constitute 20% of the gross production value, while this rate is 13.2% in triticale production. In other words, 5.01 unit gross income was obtained for one unit cost in wheat production and 7.59 unit gross income was obtained in triticale production. In terms of gross profit value, wheat production generated 4.01 lira in gross profit per unit cost while triticale generated 6.60 lira in gross profit.

Another important criterion to compare wheat and triticale production is to determine the production threshold in terms of yield and price. In other words, it is important to compare the yield and price levels in which both products can be produced or their variable costs can be met. Yield amount on the production threshold of wheat is 1304.8 and triticale is 1307.1 kilogram. Currently, the yield of wheat is 2.2 times the production threshold and the yield of triticale is 3.0 times the production threshold. The price level on the production threshold is 0.40 lira for wheat and 0.27 lira for triticale. In terms of yield and price levels on the production threshold, triticale is more advantageous than wheat. Considering the current yield and price levels, the adverse environmental and climatic conditions that may lead to a yield drop in triticale are lower than that of wheat while it is more resistant to adverse economic conditions that may lead to the manifestation of the market price.

In this study, triticale-fallow rotation system was applied as an alternative to wheat-fallow rotation system applied in dry farming conditions and fuel consumption, some operating values, yield, CO_2 emission and gross profits were determined and compared for both plants in these rotation systems. According to the results obtained;

- Fuel consumption, work performance, human and machine labor needs were close and high values were obtained for the production of both plants. In particular, minimized tilling or no-till systems have become inevitable to reduce the fuel consumption of fossil fuels, carbon dioxide emissions, reduce human and machinery labor and increase the area's work performance and energy efficiency. Thus, changes in non-renewable energy inputs can be reduced.

- As a result of the crop production, it was determined that energy was used more effectively by 41.8% by triticale compared to the wheat plant. The biggest factor that increases energy efficiency and profitability is the amount of product obtained as a result of production. In order to increase these values, it is necessary to increase the seed yield and quality characteristics as well as to reduce the inputs. This requires that necessary importance is given to seed breeding studies and national varieties suitable for ecological conditions should be developed.

- Countries should be encouraged to turn to environmentally friendly and renewable energy sources as a result of greenhouse gas emissions generated by the use of fossil fuels, the threat of global warming throughout the world and gradual depletion of fossil fuel reserves.

Figure 1. Triticale and soil tillage toprak sowing work images.

Table 1. Equipment's and the properties used in production processes of triticale and wheat.

Operation data	Agricultural operations					
	Tillage			Sowing	Spraying	Harvesting
	MP	C	CH	SM	P	CH
Effective width, cm	88.2	194.0	207.8	300	750	130
Depth, cm	25.9	15.4	6.8	5.8	-	-
Weight, kg	440	430	440	372	260	398
Speed, km h^{-1}	2	9	-	21	5.8	-
Economic life, h	2000	2000	2000	1500	1500	2000

MP: Mouldboard Plow, C: Cultivator, , CH: Combined Harrows, SM: Sowing Machine, P: Pulverisator, CH: Combine Harvester

Figure 2. Time study table, fuel gauge, speed radar and data storage unit.

Table 2. Energy equivalents of inputs and output in triticale and wheat production.

Definitions	Unit	Energy equivalents MJ unit-1	References
A. Inputs			
Diesel fuel-oil	l	56.31	Amanloo and Mobtaker, 2012
Human labour	h	2.3	Gözübüyük et al. 2012
Tractor	kg	158.5	Gözbüyük et al. 2012
Agricultural equipment's	kg	121.3	Gözbüyük et al. 2012
Fertilizer (P_2O_5)	kg	12.44	Banaeian and Zangeneh, 2011
Fertilizer (N)	kg	64.14	Banaeian and Zangeneh, 2011
Triticale	kg	13.02	Görgülü M. 2002
Wheat	kg	13.48	Görgülü M. 2002
Herbicide	kg	238	Barut et al. 2011
B. Outputs			
Triticale yield	kg	13.02	Görgülü M. 2002
Wheat yield	kg	13.48	Görgülü M, 2002
Triticale+wheat straw	kg	6.66	Görgülü M. 2002

Table 3. Some operating values of instruments used in triticale and wheat production.

Parameters	MP	C	CH	SM	P	CH
Diesel fuel-oil consumption, l ha^{-1}	20.59	10.42	6.07	5.52	1.18	10.10
Effective field capacity, ha h^{-1}	0.264	0.457	0.809	0.997	3.197	1.053
Human labor need, h ha^{-1}	4.069	2.407	1.332	2.158	0.672	2.041
Machine labor need, h ha^{-1}	3.786	2.240	1.239	1.004	0.313	0.950
CO_2 emissions, kgCO_2 ha^{-1}	59.13	29.91	17.44	15.85	3.39	29.00

MP: Moldboard Plow, C: Cultivator, , CH: Combined Harrows, SM: Sowing Machine, P: Pulverisator, CH: Combine Harvester

Table 4. The operational values of agricultural equipment's used in triticale and wheat production.

Parameters	Triticale	Wheat
Diesel fuel-oil consumption, l ha^{-1}	53.96 ± 0.30	53.80 ± 0.37
Effective field capacity, ha h^{-1}	0.103 ± 0.002	0.107 ± 0.002
Human labor need, h ha^{-1}	12.89 ± 0.22	12.47 ± 0.22
Machine labor need, h ha^{-1}	9.71 ± 0.20	9.36 ± 0.20
CO_2 emissions, kgCO_2 ha^{-1}	154.95 ± 0.86	154.49 ± 1.05
Specific CO_2 emissions gCO_2 kg$_{ürün}^{-1}$	11.57 ± 0.62	16.58 ± 0.17

Figure 3. Triticale and wheat grain and straw yield values.

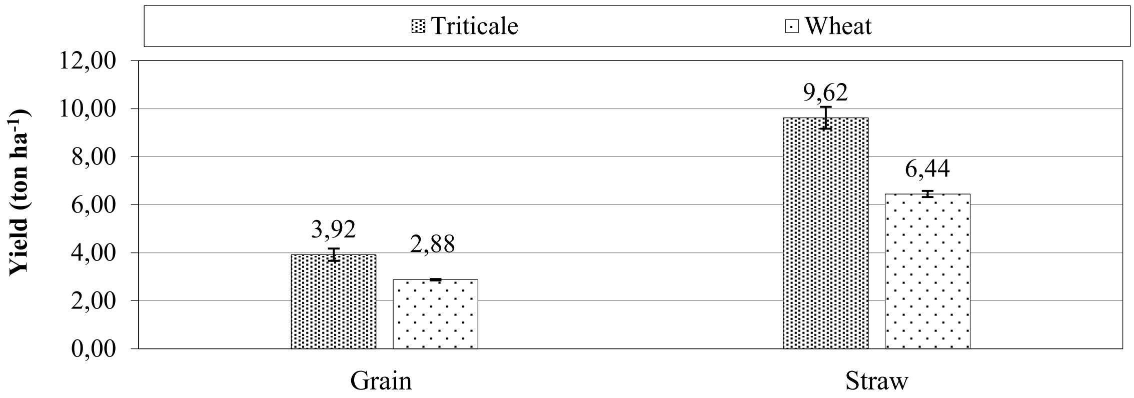


Figure 4. Energy inputs of triticale and wheat production.

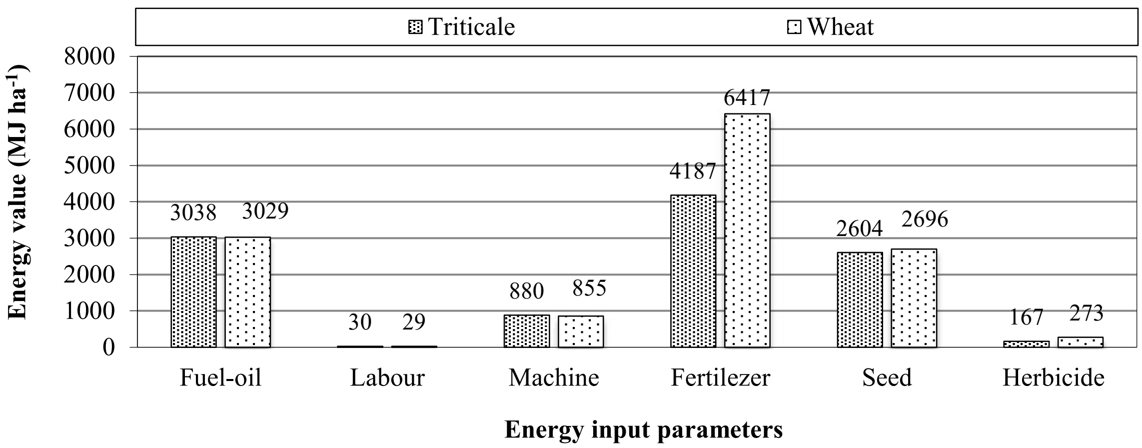


Figure 5. Share of input energies.

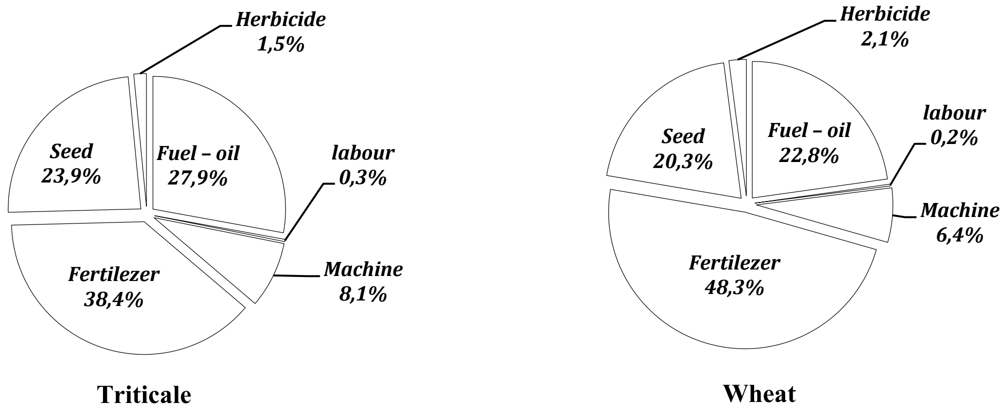


Figure 6. Energy input and output values.

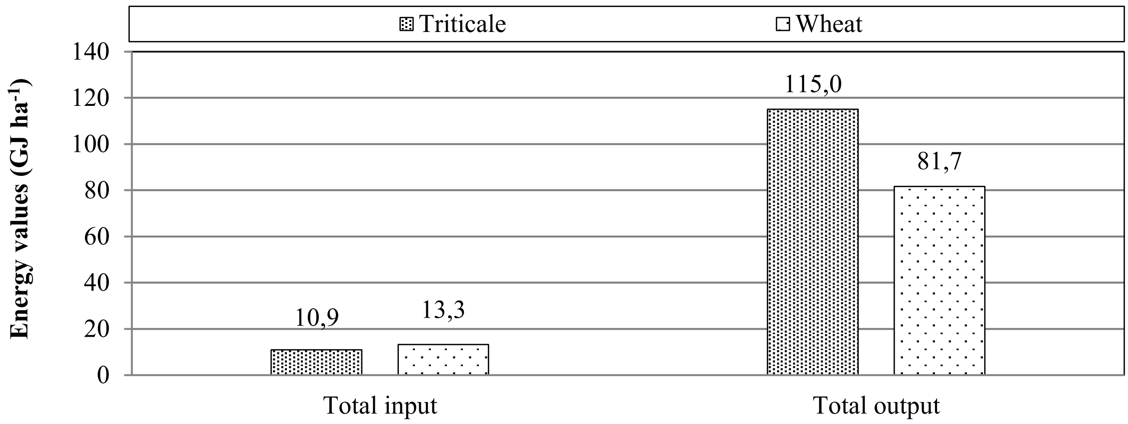
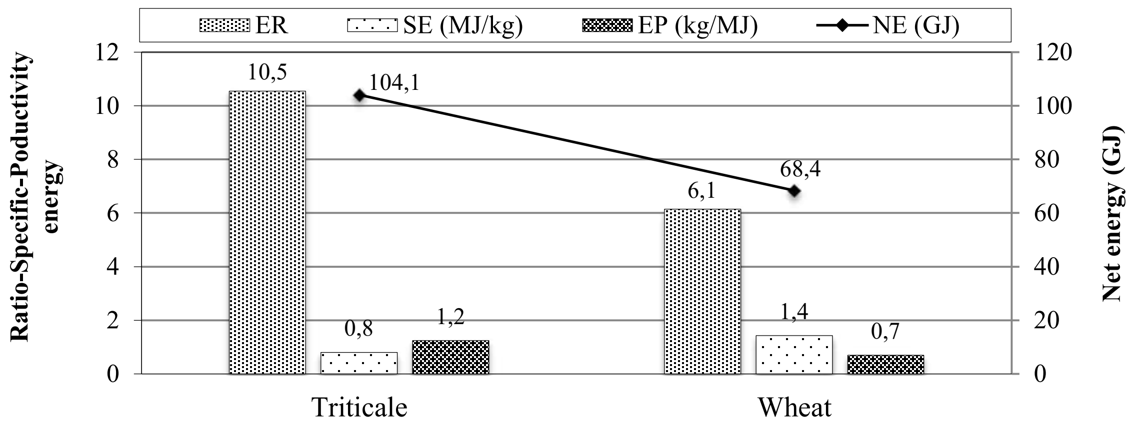
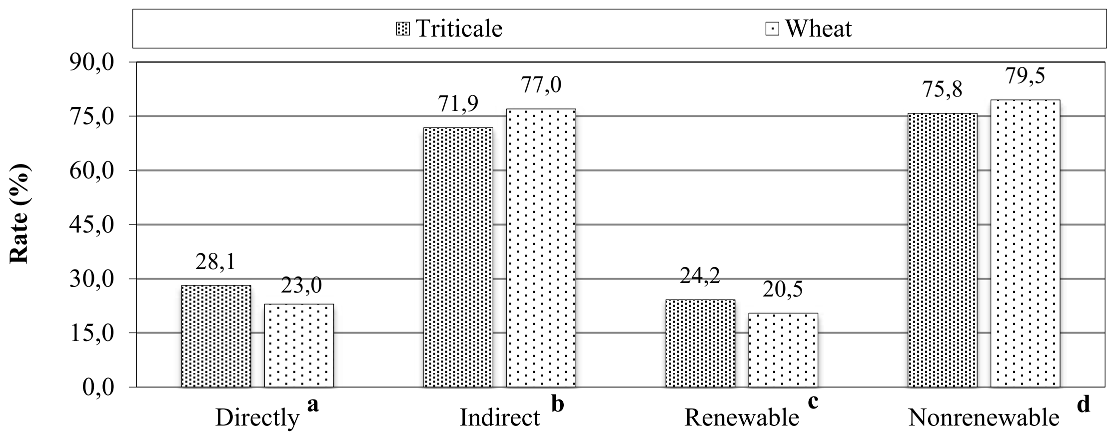


Figure 7. Energy efficiencies of triticale and wheat.



ER: Energy ratio; SE: Specific energy; EP: Energy productivity; NE: Net energy

Figure 8. Direct, indirect, renewable and non-renewable energy.



[a] Human labor, Diesel fuell-oil; [b] Machine manufactoring, Seed, Fertilizer, Herbicide energy
[c] Human labor, Seed; [d] Diesel fuell-oil, Chemical fertilizer, Machine manufactoring, Herbicide energy

Table 5. Costs and gross profits of triticale and wheat production (TL ha^{-1}).

Costs and Income		Triticale	Wheat
Seed		250.0	320.0
Fertiliser		351.7	348.5
Herbicide		21.0	61.0
Human labour		103.1	99.8
Diesel fuel		277.4	276.5
Engine oil		42.5	42.4
Variable Cost		1045.7	1148.2
Yields (kg ha^{-1})	Main products	3916.7	2875.2
	By-products	9618.3	6444.9
Product price	Main products By-products	0.80 0.50	0.88 0.50
GSÜD		7942.5	5752.6
Gross profit		6896.8	4604.4
Changing Cost Ratio (%) (Operating Expense Ratio)		13.2	20.0
Production threshold	Yields (kg ha^{-1}) Costs (TL kg^{-1})	1307.1 0.27	1304.8 0.40

Note: Variable Cost Rate: (Variable Cost / Gross Production Value)x100
Production threshold (Yield) = (Variable Cost / Price)
Production threshold (Price) = (Variable Cost /Yield)

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