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Econometric Analysis of Energy Consumption Pattern of Different Tillage Methods in Corn Cultivation

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ABSTRACT

In this study, 5 different treatments of tillage and planting with 3 replications for corn crop were considered in cultivation and industry of Naz Sari plain. The investigated tillage treatments were conventional planting of corn instead of conventional wheat planting (CT-CT), no-tillage without residues instead of no-tillage without residues (NT-NT), No-tillage is a substitute for low-tillage and planting with combine tillers (MTCO-NTR), no-tillage replacing low-tillage with no-tillage (MTNT-NTR) and no-tillage replacing no-tillage (NTR-NTR). The results of this study showed that the highest amount of net energy was in the NTR-NTR system, while the CT-CT system had the lowest amount of net energy. In fodder corn cultivation, the highest production yield belonged to the NTR-NTR system with a value of 85,756 kg/ha; which has the highest energy output with 686.04 GJ/ha. The NTR-NTR system has the best performance in energy indicators, including energy ratio, net energy, energy productivity and energy specific, due to its higher performance in fodder production than other systems, with values of 26.20, 659.86 GJ/ha, 0.075 kg/MJ and 13.27 MJ/kg, respectively. The NTR-NTR system has performed the best in the indicators of energy ratio, productivity, net and energy special, and in the economic indicators of gross profit and non-special profit. On the other hand, the NT-NT system has surpassed other systems in the energy index of the systems and the economic indicators of P and BCR.

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INTRODUCTION

In recent years, food security, which means providing enough food for a healthy human life, has become a critical issue all over the world (Wani et al., 2024). Because the increase in population and economic growth of developing countries has led to the growth of demand for food in terms of quantity and quality. The agricultural sector is one of the most important economic sectors of the country, which has made great progress in recent years and is one of the components of national income or production in most countries (Hatirli et al., 2005).

Besides supplying raw materials, agriculture is also an important consumer of some industrial products. The agricultural sector can contribute to the development of other sectors, including industry, through the transfer of surplus labor and capital. Agricultural production has a close relationship with energy consumption and is one of the major consumers and producers of energy. With the increase in the world population, the limitation of arable land and the increase in the level of human living standards, the use of energy in the production of agricultural products has increased in order to achieve a sustainable increase in food production (Rasul & Sharma, 2016). In other words, one of the important influencing factors in the sustainable production of food and agricultural products is the amount of input energy per unit of product production. On the other hand, intensive use of energy has caused some problems for human health and the environment (Ghaderpour & Rafiee, 2017).

Today, energy analysis along with economic analysis is used as an important tool to design, model and evaluate the performance of agricultural systems by many researchers in different countries (Emrani & Berrada, 2024). Examining the energy patterns and analyzing the energy input and output of apple production in Antalya province of Turkey showed that the use of chemical fertilizers (41%), mainly nitrogen, followed by electricity (29%) had the largest share in the total energy consumption (Akdemir et al., 2012).

Naseri et al. investigated energy, environmental and economic indicators for conventional and conservation tillage methods in sugarcane cultivation in dry and heavy lands. The purpose of this research was to evaluate the release of agricultural inputs, improve energy efficiency and control costs in sugarcane production. Calculations in sugarcane production were done using four tillage methods: T1 sub-breaker first time + (bulldozer (D8 sub-breaker second time + bulldozer D8 conventional operation), Alpego T2 tillage tool, Nardi T3 tillage tool, T4 sub-breaker, for the first time + bulldozer (D8 and sub-breaker five sheng).The results showed that among the four systems, due to low production costs, the T2 system is more suitable than the others. Economic analysis also showed that the total value and cost of T2 were 2255 dollars per hectare and 689 dollars per hectare, respectively. The results of cumulative exergy demand showed that the amount of non-renewable fossils from the sugarcane cutting factory is as follows for systems T1 (60.9%), T2 (59.3%), T3 (59.2%), and T4 (56%) (Naseri et al., 2021).

Calcante and Oberit made a technical-economic comparison to compare three different agricultural methods applied in paddy rice cultivation areas in Italy. One was based on conventional tillage (CT), and two methods were carried out by adopting conservative agricultural approaches, i.e. minimum tillage (MT) and no tillage (NT). Data on production inputs (seeds, fertilizers, agrochemicals, fuel) and labor time for each technique were measured over the entire production season in three experimental farms. The results of this study showed a significant reduction of total costs obtained with minimal (-16%) and no tillage (-19%) compared to conventional tillage (Calcante & Oberti, 2019).

Król-Badziak *et al.* in a study evaluated the sustainability of no-tillage (NT), reduced tillage (RT) and conventional tillage (CT) in corn monoculture based on economic, environmental and social aspects. The results showed better performance for CT in economic and social criteria while NT and RT had better performance in environmental criteria. The final evaluation showed the highest overall performance for CT, followed by RT and NT (Król-Badziak et al., 2021).

Martin-Gorriz *et al.* analyzed carbon emissions associated with farm operations and economic benefits for two organically grown almonds (Martin-Gorriz et al., 2020). Soil management systems in this case include: conventional tillage

(CT), reduced tillage (RT), reduced tillage with green manure (RTG); and no tillage (NT). A life cycle assessment of cradle-to-farm gates was used based on long-term data from two farms. The obtained results showed that the NT strategy provided the lowest greenhouse gas emissions, but its efficiency was also the lowest, which negatively affects its economic viability even considering subsidies. The RT strategy reduced emissions and improved the profit/emission ratio, while the RTG strategy increased emissions and reduced the profit/emission ratio as a result of seed use.

The use of protective tillage methods to protect agricultural soil and reduce fuel consumption, which is achieved by minimizing car traffic in the field, in addition to the optimal consumption of fossil fuels, causes a significant reduction in harmful environmental effects, including air pollution (Manafi Dastjerdi & Lari, 2017). Tillage and planting are the main operations in an agricultural product production system that affect the product yield, soil quality and energy input. In order to evaluate sustainability in the production of agricultural products, it is necessary to consider energy consumption according to indicators such as economic indicators (Unakitan et al., 2010). One of the basic goals of any production sector, such as the agricultural sector, is to increase production and reduce costs (Muangprathub et al., 2019).

Therefore, it is important to determine economic indicators by determining production costs and product performance, as well as determining the profit-to-cost ratio (Skaf et al., 2019). Based on this, the purpose of this study is to investigate the economic efficiency of different tillage systems on the corn crop and to investigate the difference in energy consumption in different machine systems in the native conditions of Naz Sari field of agriculture and industry. To achieve this goal, the calculation and analysis of various economic and energy indicators was done.

MATERIALS AND METHODS

The experiments were carried out in the Dasht Naz region of Miandorud city, 29 kilometers northeast of Sari, in the 2023-2024 crop year and with the cooperation of the Dasht Naz Agricultural Company of Sari. This region is located in latitude (36.40) and longitude (53.10) and has a moderate climate in terms of weather (Fig. 1). The area of agricultural land was 982 hectares with silty-clay soil texture, including 51% clay, 42% silt and 7% sand. The experiment was conducted in the form of a randomized complete block design with 5 different treatments for tillage and planting fodder corn in crop rotation with wheat and in 3 replications. The dimensions of each plot were about 35 meters by 50 meters. Also, the distance between the rows was 75 cm. The number of crop rows in each plot was about 47 rows. In this experiment, corn treatments have replaced wheat treatments (previous land cultivation). The investigated tillage treatments were conventional planting of corn instead of conventional wheat planting (CT-CT), no-tillage without residues instead of no-tillage without residues (NT-NT), No-tillage is a substitute for low-tillage and planting with combine tillers (MTCO-NTR), no-tillage replacing low-tillage with no-tillage (MTNT-NTR) and no-tillage replacing no-tillage (NTR-NTR).

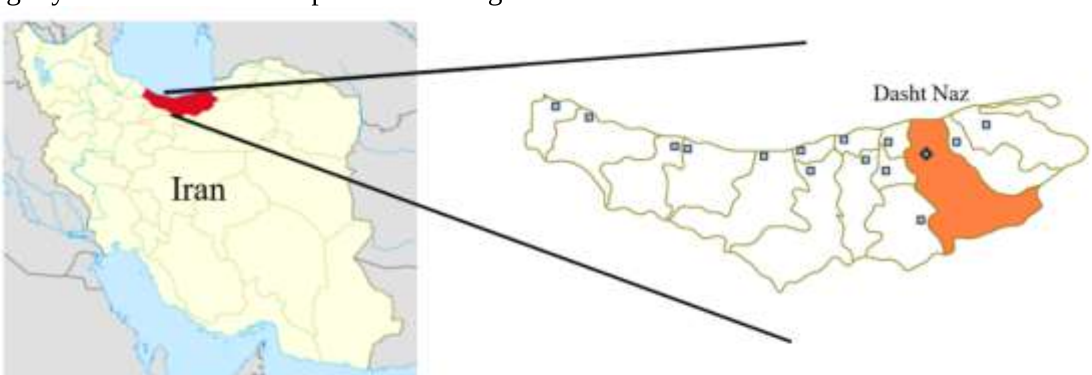

Figure.1. The location of Dasht Naz Sari in Iran

The conventional planting method of the company included the use of moldboard plows, discs, combine harvesters and other machines shared with other systems. In this research, two no-tillage treatments using a direct tiller and two low-tillage treatments using a mixed tiller and a direct tiller or a mixed tiller and a combined tiller were also evaluated.

The working method was that first, the ground was turned upside down with a moldboard plow to a depth of 25 cm at a speed of 3 to 4 km/h, and then a disk was used. The no-tillage treatments included planting corn with a direct seeding machine (SEMEATO NO TILL SHM 13.11) in the residues of the previous crop (wheat) and also in the field without residues. Each of the treatments was measured in three repetitions, then economic and energy indicators were calculated and compared for each treatment. Excel 2019 software was used to collect data and basic calculations in this research. Also, the data were analyzed by IBM SPSS Statistics 27.0.1.

Economic indicators

In this study, various economic indicators including gross profit (GR), benefit-cost ratio (BCR) and economic productivity (P) were investigated (eqs 1, 2 and 3). Gross profit is obtained by subtracting the variable cost and net profit by subtracting the total cost of production from the income per hectare. Profit-cost ratio and economic productivity are calculated by dividing income and yield by the total cost of production per hectare, respectively. According to the guaranteed sales rate of fodder corn per kilogram, the price of fodder corn produced for each tested treatment was calculated at the scale of one hectare.

According to the consumption cost for each treatment and the average yield of fodder corn obtained from each treatment in one hectare, the total price of each kilogram of fodder corn produced for each system was obtained. Also, dividing the non-special profit by the revenue from each treatment multiplied by 100 shows the percentage of non-special profit of the sale. This practical index shows the profit percentage of each system well (Gökdoğan et al., 2019). According to the guaranteed sale rate of fodder corn based on 0.11 dollars per kilogram in Iran in 2024, the price of fodder corn produced for each tested treatment was calculated at the scale of one hectare.

Income – Variable cost (dollar. ha^{-1})
GR = (dollar. ha^{-1}) (1)

profit (dollar. / Total cost (dollar. ha^{-1})
BCR = ha^{-1}) (2)

= yield (kg ha^{-1}) / Total cost (dollar. ha^{-1})
P (3)

Energy calculation of machines

Considering the use of similar machines in the region, especially tractors in most of the farms, in order to calculate the energy equivalent of machines and equipment, it is necessary to multiply these numbers by the total weight of the machine to get the total energy of the machine. If this energy is divided by the hourly useful life of the car, the equivalent energy for one hour of car use is obtained. Equations 4 to 7 were used to calculate these indices (Gokdogan et al., 2017).
Energy coefficients for fodder corn production inputs and outputs are listed in Table 1.

Table 1. Energy coefficients for inputs and outputs Crop production (or forage maize) (Lal et al., 2003)

Title	**Unit**	**Energy content (MJ/Unit)**
Manpower	h	1.96
Machinery and implements	h	62.7
combine harvester	h	83.5
Gasoline	Lit	56.31
Electricity	kW/h	11.93
N	kg	66.14
Phosphate	kg	12.44
liquid fertilizer	Lit	102
insecticide	Lit	120
Herbicide	Lit	85
Fungicide Wheat	Lit	115
Seed Corn	kg	100

RESULTS AND DISCUSSION

Energy analysis of cultivated corn

In this research, the amount of energy in the fuel consumption section for each operation was calculated by multiplying the amount of fuel consumed by the fuel-to-energy conversion factor (per liter is equivalent to 37 MJ of energy).The energy equivalent of inputs used to produce fodder corn in one hectare of tested land is presented in Table 2. As Table 2 shows, except for fertilizers, poisons and consumed seeds, other inputs differ from each other in terms of input energy in different agricultural operations. The conventional system among tillage and planting systems has consumed more fuel for agricultural operations. For the conventional system, due to the increase in the number of machines used and the subsequent consumption of fuel, the energy input of the machine and manpower is more.

In the comparison of 5 systems, for CT-CT, NT-NT, MTCO-NTR, MTNT-NTR and NTR-NTR, the difference in performance and energy output of the systems is not significant at the 5% level. The CT-CT system has a big difference in diesel fuel consumption with other systems, and consequently, the energy input of this system is evident. But on the other hand, the lower performance and as a result the lower output energy of this system compared to other systems can be considered. Table 2 also shows that the NT-NT system had the lowest input energy with a slight difference from other no-tillage systems, and this difference was not significant in the statistical analysis. This difference is only due to less energy consumption in the indirect energy sector of the car and the direct energy of the fuel. Other protection systems also have less input energy than the conventional system. However, this difference was not significant in the statistical analysis. In the conventional cultivation of the Naz plain, the use of a cyclotiller and double disk more than other systems is a clear reason for more energy consumption.

Energy ratio $= \text{Energy Output} / \text{Energy input} \ (MJ.ha^{-1})$ (4)

Energy productivity $= \text{Output} \ (kg.ha^{-1}) / \text{Energy input} \ (MJ.ha^{-1})$ (5)

Specific energy $= \text{Energy input} \ (MJ.ha^{-1}) / \text{Output} \ (kg.ha^{-1})$ (6)

Net energy $= \text{Energy Output} - \text{Energy input} \ (MJ.ha^{-1})$ (7)

Table 2. Energy consumption of inputs and output in corn production

Pretreatment (wheat)	**CT ($MJ\ ha^{-1}$)**	**NT ($MJ\ ha^{-1}$)**	**NTR ($MJ\ ha^{-1}$)**	**NTR ($MJ\ ha^{-1}$)**	**NTR ($MJ\ ha^{-1}$)**
Treatment (corn)	**CT**	**NT**	**MTCO**	**MTNT**	**NTR**
Systems	**CT-CT**	**NT-NT**	**MTCO-NTR**	**MTNT-NTR**	**NTR-NTR**
Inputs					
Labor force	30.42	28.28	28.43	28.43	28.4
Machinery	357.15	247.43	252.13	252.13	252.13
Diesel fuel	7600.04	4180.34	4411.21	4411.21	4411.21
Herbicide, fungicidal, insecticidal	771	771	771	771	771
Nitrogen (n)	12352.31	12352.31	12352.31	12352.31	12352.31
Phosphate (P2O5)	1244	1244	1244	1244	1244
potassium (k_2o)	1115	1115	1115	1115	1115
liquid fertilizer	204	204	204	204	204
Electricity	2799.19	2799.19	2799.19	2799.19	2799.19
Seed	3000	3000	3000	3000	3000
Total energy input	29830.28	25941.56	26177.28	26177.28	26177.28
Output energy	648711.11	668266.66	661155.55	659377.77	686044.44

Analysis of energy indicators of different systems in corn cultivation

Table 3 shows different energy indicators in each system for fodder corn production. Direct energies include the energy of diesel fuel inputs, labor and electricity. Meanwhile, indirect energies include seed energy, chemical fertilizer and machine energy. Also, renewable energy sources in wheat production include labor and seeds, while other inputs are known as non-renewable energy sources. The results showed that the highest amount of energy ratio and energy productivity is related to the production of fodder corn when the NTR-NTR system is used, so that the values of these indicators are reported as 26 and 0.075 for this system.

The results of this study also showed that the highest amount of net energy was in the NTR-NTR system, while the CT-CT system had the lowest amount of net energy. The production of fodder corn in the CT-CT method in the tested area had the highest specific energy, while this index was the minimum for the production of this product in the NTR-NTR method. These results indicate that to produce one kilogram of fodder corn, CT-CT and NTR-NTR systems had the highest and lowest energy consumption.

Table 3. Energy indicators of systems in corn cultivation

Pretreatment (wheat)		**CT**	**NT**	**MTCO**	**MTNT**	**NTR**
Treatment (corn)		**CT**	**NT**	**NTR**	**NTR**	**NTR**
Systems		**CT-CT**	**NT-NT**	**MTCO-NTR**	**MTNT-NTR**	**NTR-NTR**
Title	**Unit**					
Energy ratio	-	21.74	25.76	25.25	25.18	**26.20**
Energy productivity	kg MJ^{-1}	0.050	0.066	0.067	0.066	**0.075**
Specific energy	MJ kg^{-1}	19.88	15.06	14.72	14.95	**13.27**
Net energy	GJ ha^{-1}	618.88	642.325	634.97	633.200	**659.86**
Direct energy	GJ ha^{-1}	10.42	7.007	7.238	7.238	**7.238**
Indirect energy	GJ ha^{-1}	19.40	18.93	18.93	18.93	**18.93**
Renewable energy	GJ ha^{-1}	3.03	3.028	3.028	3.028	**3.028**
Non-renewable energy	GJ ha^{-1}	26.79	22.91	23.14	23.14	**23.14**
Energy Systems (Machinery, Diesel, Human	GJ ha^{-1}	7.98	4.45	4.69	4.69	**4.69**

The innovative index "Energy of Systems" is presented in Table 3 to better show the difference in energy consumption in systems that include energy from diesel fuel, machines and human power. The results show that the CT-CT system with 7.987 GJ/ha and the NT-NT system with 4.456 GJ/ha have the highest and lowest values for the energy index of the systems, respectively. And this itself is a proof of reducing energy consumption in conservation tillage.

Fig 2 shows that the renewable energy of all five systems are equal to each other, which is due to the same energy content of seeds and human resources for all treatments. The content of manpower is slightly higher in the conventional treatment, but this difference is insignificant. The CT-CT system has consumed the most non-renewable energy, which is due to the higher consumption of diesel fuel and energy from machines. The direct and indirect energy of the conventional system is more than the four protection systems, and this difference between the systems was not significant in the statistical analysis at the 5% level. The minimum direct energy consumption belongs to the NT-NT system, the main factor of which is the lower consumption of diesel fuel by the machines used in this system. The results of the research conducted on the energy consumption of sunflower production in Turkey showed that the share of non-renewable energy was more than the share of renewable energy and the ratio of indirect energy was more than direct energy, which is due to the high consumption of chemical fertilizers (Uzunoz et al., 2008). The results of the present research were consistent with these results.

Table 4 shows the results of variance analysis of yield and energy output of fodder corn in the use of different tillage and planting systems. According to the results of this table, there is no significant difference between corn yield in different tillage and planting methods. Also, the variance analysis of fodder corn energy output shows no significant difference in different tillage and planting methods for this index.

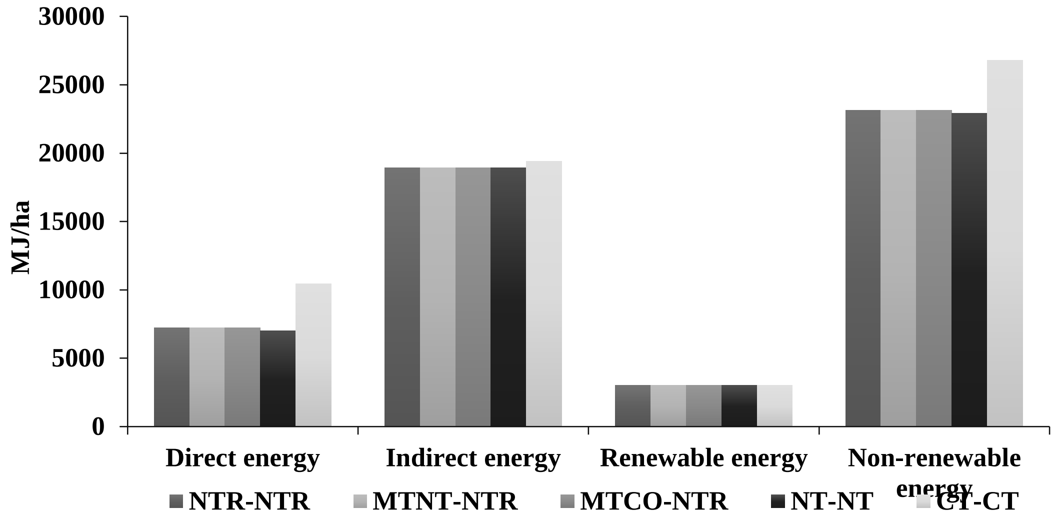

Figure. 2. Direct, indirect, renewable and non-renewable energy indicators of systems in corn cultivation

Table 4. Analysis of corn yield and energy input variance using different tillage and planting systems

Sources variance	df	Average performance squares	Average output squares
Tillage and planting systems	4	8962963 ns	573629629 ns
Error	8	121146296	7753362964
Total	14	-	-
CV	-	13.24	13.24

ns: Lack of significance

Economic analysis of input-output of corn production

The results of estimating the economic indicators of fodder corn production in different tillage and planting systems are shown in Table 5. According to the results, it can be seen that in economic indicators such as non-special profit, BCR, P to sales, the NT-NT system is superior to other systems with a slight difference. But the thing to think about is that in two indicators of GR and non-specific profit, the NTR-NTR system has a better situation with a slight difference than the NT-NT system and with a bigger difference with other systems. This difference is due to the cost of wheat straw that was not collected and left on the ground. Wheat straw with a value equivalent to 0.037 dollars per kilogram was left in the ground in no-tillage treatments and its input cost was calculated and compared to other treatments. The values in the table show a slight difference in the economic indicators between the protection systems. While, this difference between conventional system and protection systems is more. But again, this difference was not significant in the statistical analysis.

The results showed that the vastness of the fodder corn cultivated land in Dasht Naz and having the necessary infrastructure for agriculture and industry, including machine maintenance and repair workshops, self-sufficiency in the production of fodder corn seeds, the use of machines owned by Dasht Naz Also, the use of airplanes as a cost-effective technology is a proof of the increase of the BCR index compared to similar researches, even in the mentioned conventional system of agriculture and industry, which in this test had the lowest amount of economic indicators. Also, protective systems with less consumption of machine inputs, fuel and even manpower hours have reduced production costs and increased income, which is well shown by looking at table 5 in economic indicators.

Table 5. Economic Indicators of Systems in Corn Cultivation

Pretreatment (wheat)		**CT**	**NT**	**MTCO**	**MTNT**	**NTR**
Treatment (corn)		**CT**	**NT**	**NTR**	**NTR**	**NTR**
Systems		**CT-CT**	**NT-NT**	**MTCO-NTR**	**MTNT-NTR**	**NTR-NTR**
Economic Indicators	**Unit**					
GR	$ ha^{-1}	60506.47	64654.41	61767.79	61517.65	65267.87
Non-special profit	$ ha-1	56016.13	60163.68	57277.46	57027.44	60777.46
BCR	-	1.71E-03	1.83E-03	1.72E-03	1.71E-03	1.79E-03
P	Kg $$^{-1}$	1.01E-06	1.08E-06	1.01E-06	1.01E-06	1.05E-06

According to the cost for each treatment and the average fodder corn yield of each treatment, the cost price per kilogram of fodder corn produced for each system was obtained (Table 6). The percentage of non-special profit to sales is obtained by dividing the non-special profit by the income from each treatment multiplied by 100, which shows the percentage of profit from each system.

According to Table 6, the results showed that the highest and lowest selling prices belong to NTR-NTR and CT-CT systems, respectively. According to the results, for the conventional system, taking into account the selling rate of 0.11 dollars in 2024 in Iran for each kilogram of fodder corn, it had a profit of 61.4% per kilogram. While this number for NTR-NTR and NT-NT systems, 63 and 64.02 percent profit per kilogram was obtained, respectively. By continuing to calculate these figures and comparing between the systems, it is concluded that maybe the index of the percentage of non-specific profit to better sales can show the differences between the tested systems. The values of this index for each system are listed in Table 6. Looking at the values obtained for the economic indicators of conservation systems in Tables 5 and 6, it was found that no-tillage systems performed better in these indicators. In total, protection systems NT-NT, NTR-NTR, MTCO-NTR, MTNT-NTR and finally CT-CT system have maximum to minimum values in these economic indicators in terms of profit-to-cost, productivity, percentage of non-specific profit to sales respectively.

As can be seen in Table 5, the two systems NTR-NTR and NT-NT have the highest gross profit and non-special profit. Because gross profit is the difference between income and variable costs and the non-specific profit is the result of the difference of income and total costs, therefore, the NTR-NTR system has the highest performance and, subsequently, the highest selling price, and on the other hand, the NT-NT system has the lowest input cost. These two systems have obtained more gross profit and non-special profit than other systems in the difference of income and variable cost and total.

Also, the NT-NT system in fodder corn cultivation has the highest value in the benefit-to-cost index due to the lower cost of not using the chopper stem for the residues of the previous crop and not having the cost of wheat straw for the residues. The NTR-NTR system is placed after NT-NT in this economic index due to its higher performance and higher sales price. This is despite the fact that the conventional system does not have a favorable situation in this index even though there is no cost of straw for residues. Comparison of economic efficiency for the tested systems showed that the NT-NT system has the best performance ratio compared to other systems. Of course, the performance of the NTR-NTR system is higher than that of NT-NT, but the no-tillage system without residues has been more successful in this economic index by spending less on inputs.

Table 6. Applied Economic Indicators of Systems in Corn Cultivation

Pretreatment (wheat)		**CT**	**NT**	**MTCO**	**MTNT**	**NTR**
Treatment (corn)		**CT**	**NT**	**NTR**	**NTR**	**NTR**
Systems		**CT-CT**	**NT-NT**	**MTCO-NTR**	**MTNT-NTR**	**NTR-NTR**
Economic Indicators	**Unit**					
Selling price	\$ ha^{-1}	9122.43	9397.06	9297.46	9272.45	9647.47
The finished price per kilogram	\$ kg^{-1}	4.34E-02	4.05E-02	4.32E-02	4.33E-02	4.16E-02
Non-special profit percentage for sales	%	61.40	64.02	61.61	61.50	63

CONCLUSIONS

In fodder corn cultivation, the highest production yield belonged to the NTR-NTR system with a value of 85,756 kg/ha; which has the highest energy output with 686.04 GJ/ha. But in contrast to the NT-NT system, with 25.94 GJ/ha, it has the lowest input energy due to the lower consumption of machine inputs, diesel fuel and manpower. The NT-NT system has the lowest direct and non-renewable energy consumption with 7.007 and 22.91 GJ/ha. The NTR-NTR system has the best performance in energy indicators, including energy ratio, net energy, energy productivity and energy specific, due to its higher performance in fodder production than other systems, with values of 26.20, 659.86 GJ/ha, 0.075 kg/MJ and 13.27 MJ/kg, respectively.

Finally, in terms of energy indicators, the NTR-NTR system is introduced as the best system. The NTR-NTR system with the highest selling price due to the highest yield of corn fodder has the highest GR equivalent to \$65,267.87 per hectare. While the NT-NT system with lower performance than the NTR-NTR system, and the percentage of non-special profit to sales of 64, is the least expensive system in total and is superior to other systems. This factor causes the NT-NT system in economic indicators; including BCR and P, have the best performance among all systems. Therefore, it can be concluded that the NT-NT system is the optimal system in terms of economic indicators in corn cultivation. With a comparison between tillage and corn planting systems, it can be concluded that conservation systems have shown better performance in energy and economic indicators, among which NT-NT and NTR-NTR systems have a more favorable situation than other systems. The NTR-NTR system has performed the best in the indicators of energy ratio, productivity, net and energy special, and in the economic indicators of gross profit and non-special profit. On the other hand, the NT-NT system has surpassed other systems in the energy index of the systems and the economic indicators of P and BCR.

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