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# AN ANALYSIS OF ENERGY USE AND INPUT COSTS FOR RADISH PRODUCTION IN TURKEY

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***Abstract***

*This research aimed to determine the comparison between the cost of energy and the cost price of producing radishes in Osmaniye Province in Turkey, which is an important source of income in agriculture in Turkey. A questionnaire was used to collect data on radish production from the intended target population 149 radish farms in 2019. The sample was calculated using Neyman's method. Based on a sample size the error was defined as 5 percent for 95 percent reliability. The socio-economic characteristics of the farmers were used to present analysis and also secondary data were also used in the research to deepen our knowledge. The results showed that the input energy was 2,946.574 MJ $da^{-1}$, of which the highest share was related to deep plowing, irrigation, first watering after transplanting, and second plowing with 21.60, 20.07, 19.84 and 12.08%, respectively. The lowest input was belong to Harvest and Packaging with 0.03%. Labor cost (70.75%), fuel cost (14.41%), and material used 14.84%.In addition, the production cost and sales price ( $/ ton) of radish are obtained at 21.69 and 40.21 respectively. We find that the rate of profit from agricultural income was 87.82% while that of energy was 61.38%.*

**Key words**: *energy, radish production, input, Turkey*

## INTRODUCTION

Energy is the main driver of human development. The civilization of man is largely the story of progress in energy harnessing, that is, the conversion of energy into a more useful form. Fossil energy is a major resource in agricultural production and is important for the user and supplier of energy in the form of bio-energy in agriculture. According to FAO (2000) [8] energy in agriculture offers significant opportunities for rural development as well as tools to mitigate climate change by replacing fossil fuels with bio-energy. Ozkan et al. (2004) [24] in agriculture, energy is important in terms of agricultural production and agricultural processing for value addition. The increase in trade and production opportunities as a result of rapid population growth, industrialization, urbanization, and globalization increases the demand for energy use and natural resources. Energy use in agriculture is increasing with increasing population, limited arable land, and increasing living standards. These factors have led to an increase in energy inputs, increasing efficiency, and the desire to make things easier by minimizing labor-intensive applications (Akdemir et al, 2012)[3]. Energy plays a key role in economic and social development. Today, there is a lack of leadership in terms of rural energy development policy in agriculture (FAO 2000) [8].

Several methods of energy analysis have been described and include statistical analysis, input-output analysis, and process analysis (Fluck and Baird 1980) [10]. Statistical analysis using global statistics such as fertilizer sales is used to arrive at an estimate of total energy consumption but does not achieve the precision that can be achieved with other methods. The input-output analysis uses a square matrix of energy inputs and is most valid for nationwide analysis. Zucchetto and Bickle (1984) [44] state that input-output analysis can also be used appropriately when analyzing a farming system with multiple outputs. Process analysis is considered the most appropriate and accurate data analysis method for a single outlet production system and was used in this study. The processes used to produce a crop are identified and analyzed to quantify their respective energy inputs (Fluck and Baiard 1980) [10]. According to Vinten Johansen et al. (1990)[39] the results can then be expressed as energy productivity in terms of joules of energy required per kilogram of crop yield.

The radish is produced in all seasons of the year, although its caloric intake is low, it is rich in vitamins and minerals, and it is eaten fresh and cooked, it is one of the first vegetables produced in the history of humanity, red radish, white radish, horseradish, etc. many different varieties etc. The radish has an important place among vegetables. Turkey radish production is about 7 million tons per year and approximately 200 thousand tons of radishes are produced annually. Turkey’s radish cultivation area, production 158,029 ton/2009 and 196,984 ton/2018, and yield development by years (TURKSTAT, 2019; Nermin, 2019) [38, 23].

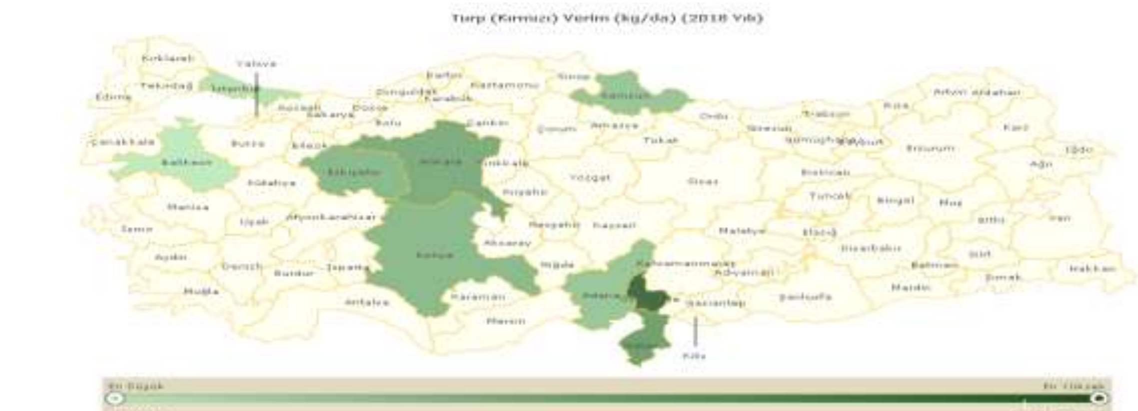
The average annual area of radish cultivation over the past 5 years is 64,000 da. Despite this development of the cultivation area 64,121da /2009-62,931da /2018, the yield of radish has increased over the years. Indeed, the yield which was 2.46 tons/d in 2009 reached 3.13 tons/d in 2018 with an increase of 27%.

The volume of production, on the other hand, grew along with the increase in productivity and increased by 25% compared to 2009, and the average production of the last 5 years was 197,642 tons. The amount of annual radish exports fluctuates over the years, it is on average 780 tons per year. Most of the production is used for domestic consumption. Also, Turkey is self-sufficient in radish production (TÜİKb, 2019) [38].

Map 1 shows us  Osmaniye Province ranks first for radish production in Turkey, both in terms of cultivation area and production. The other provinces where the cultivation area is dense such as Samsun (6.01%), Ankara (3.27%), Karaman (2.81%), and Kahramanmaraş (2.77%) (Akdemir and Ismailla, 2022) [2].  In terms of radish yield, it is seen that Osmaniye has higher productivity. Osmaniye province provides 71.19% of Turkey's radish production, which remained stable between 2009 and 2018, production increased from 112,500 tons to 140,225 tons with an increase of 24.64%.

The yield increase was effective and increased from 3.00 kg/day to 3.52 kg/day over the specified period. Osmaniye province is one of the most important livelihoods of radish growers. According to the Ministry of Agriculture and Forestry, radish occupies the first place in the return rates of products grown in many districts of Turkey.

The objective of this research aimed to determine the comparison between the cost of energy and the cost price of producing radishes in Osmaniye.



Map 1**.** Radish yield by provinces in Turkey
Source: Adapted from TÜİK, 2019 [38].

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## MATERIALS AND METHODS

This study is carried out in Osmaniye Province in Turkey. The surveys were conducted among 149 radish producers randomly selected in the villages using the stratified random sampling technique according to the survey method. The sample was calculated using Neyman's method (Yamane, 1967) [42]. The sample size error was set to 5% for 95% confidence (Akdemir et al. 2012) [3]. Primary data and secondary data were used in the study to contribute to the analysis. The calculation of energy inputs is based on the time required for each operation, the number of workers, and the machinery and inputs used (seeds, fertilizers, and chemicals)(Khoshnevisan et al. 2013, Singh, 2002; Mandal, 2002) [13, 36, 17]. Table 1 Energy equivalents of inputs used in radish production. There is a wide variation in energy equivalents used to denote energy input compared to manufacturing means of production in terms of primary energy input (Rathke and Diepenbrock, 2006) [32]. Energy is mainly used in agricultural processes for several activities. Table 1 shows that the total human energy use on each farm was calculated with appropriate conversion factors of 1 man-hour = 1.96 MJ $ha^{-1}$. The mechanical energy used on the selected farms including tractors and diesel engines are calculated based on total fuel consumption (liter $ha^{-1}$). Electric power was used to operate the irrigation pump for transporting water. Various energy efficiency parameters were determined by evaluating the relationship between energy consumption and total production and yield per hectare.

Table 1. Energy equivalents of inputs and outputs

| Items | Unit | Energy content ($MJunit^{-1}$) | Reference |
|---|---|---|---|
| Human labour | h | 1.96 | Houshyar et al. (2017); Mani et al. (2007) [12, 18]. |
| **Machinery** | | | |
| Tractor 50 kw | h | 41.4 | Khoshnevisan et al. (2013); Fluck 1985 [13, 9]. |
| Plough | h | 22.8 | |
| Sprayer | h | 23.8 | |
| Wagon | h | 71.3 | |
| Pump | h | 2.3 | |
| **Fertilizers** | | | |
| N | Kg | 60.60 | Singh, (2002); Mandal, (2002) [36, 17]. |
| P | kg | 11.1 | |
| K | Kg | 6.7 | |
| Insecticides | Kg | 278 | Lal (2004); Dalgaard et al. (2001) [16, 5]. |
| Fungicides | Kg | 276 | Graefe et al. (2013); Wells (2001) [11, 40]. |
| Farmyard manure (dry matter) | Kg | 0.3 | Mohammadi et al. (2014); Shrestha (1998) [20, 34]. |
| Diesel | 1 | 56.31 | Dyer and Desjardins (2006); Pimentel and Pimentel (2007) [6, 28]. |
| Electricity | kwh | 11.93 | Singh, 2002; Mandal, 2002 [36, 17]. |
| Water for irrigation | $m^3$ | 0.63 | Houshyar et al. (2017); yaldiz et al. (1993) [12, 41]. |
| Fruit | Kg | 2.4 | Strapatsa et al. 2006 [37]. |

Source: [3, 12, 18, 13, 9, 36, 17, 16, 5, 11, 40, 20, 34, 6, 28, 36, 17, 41, 37].

Using the formula suggested below in the literature by (Akdemir et al. 2012; Pishgar et al. 2011) [3, 29].

$$\boldsymbol{Energy\ ratio} = \frac{\boldsymbol{Energy\ output}\ (\boldsymbol{Mjha^{-1}})}{\boldsymbol{Energy\ input}\ (\boldsymbol{Mjha^{-1}})}$$
................................................................(1)

$$Specific\ energy = \frac{Energy\ input\ (Mjha^{-1})}{Output\ (kgha^{-1})}$$ ..................................................................(2)

$$Energy\ productivity = \frac{output\ (kgha^{-1})}{Energy\ input\ (Mjha^{-1})}$$ .................................................................. (3)

$$Energy\ intensiveness = \frac{Energy\ input\ (Mjha^{-1})}{Cost\ of\ production\ (YTLha^{-1})}$$ .................................................................. (4)

$$Net\ energy\ yield = Energy\ output\ (Mjha^{-1}) - Energy\ input(Mjha^{-1}$$ ..................................................................(5)

The ratio of energy input to input shows the efficiency of energy input as well as the marginal increase in output due to the unit increase in energy input. Singh et al. (2007) [35]. The ratio is higher at the lowest energy input and lower at the highest energy input, indicating that the reduced rate of return applied to energy input is low. It is in no way an indicator of the economic efficiency of agriculture. Rathke and Diepenbrock, (2006) [32] it is therefore not surprising that we find high-yield agricultural chains operating with very low energy efficiency. Energy inputs are examined as direct and indirect, renewable and non-renewable, and commercial and non-commercial.

## RESULTS AND DISCUSSIONS

### Socio-economic characteristics of the radish farms

Table 2 shows us the average household size of the farm family in the research was almost 5 people. The average age of farmers was 51 years old. Similarly, to those obtained by Miassi and Akdemir (2022) [19] that the average age of producers is 47 years old. Most farmers have experienced an average in agriculture of 27 years. Our results demonstrated that 16.8% of the farmers in the sample are primary or lower school graduates, 63.1% are middle or high school graduates, and 20.1% are university graduates.

Table 2. Socio-economic characteristics of the radish farms

| Variables | | N | % | Average |
|---|---|---|---|---|
| Age | 20-40 | 31 | 20.8 | 35.39 |
| | 41-60 | 89 | 59.7 | 51.29 |
| | More than 60 | 29 | 19.5 | 66.24 |
| Experience (years) | 1-15 | 30 | 20.1 | 11.73 |
| | 16-35 | 77 | 51.7 | 26.99 |
| | More than 35 | 42 | 28.2 | 44.55 |
| Household size | 1-3 | 20 | 13.4 | 2.35 |
| | 4-6 | 106 | 71.1 | 4.87 |
| | More than 6 | 23 | 15.4 | 9.48 |
| | Primary school or lower | 25 | 16.8 | - |
| | Middle school-high school | 94 | 63.1 | - |
| Education | University | 30 | 20.1 | - |
| Non-farm income | Yes | 75 | 50.3 | - |
| | No | 74 | 49.7 | - |
| | Yes | 134 | 89.9 | - |
| Tractor presence | No | 15 | 10.1 | - |
| | 1-50 da | 33 | 27.7 | - |
| | 51-199 da | 51 | 42.9 | - |
| Owned land (da) | More than 200 da | 35 | 29.4 | - |
| Multiple Shared Land (da) | 10-30 da | 5 | 25 | - |
| | 31-199 da | 9 | 45 | - |
| | More than 200 da | 6 | 30 | - |
| | 0-75 da | 17 | 22.7 | - |
| Rental Land (da) | 76-330 da | 40 | 53.3 | - |
| | 331-3,000 | 18 | 24 | - |

Source: Survey, 2019.

This result is not similar to Adisu (2020) [1], according to which the educational status of the respondents revealed that around 53.5% were unable to read and write. The majority of farmers own tractors 89.90%. Owning a tractor reduces the need for external labor (Kormawa et al. 2019) [15]. A tractor is much more cost-effective when deployed over a large area and also makes it easier to carry out activities and reduces the need for outside labor. Owned land (da), Multiple Shared Land (da), and Rental Land (da) in the study households were the most dominant with 42.9; 45 and 53.3% respectively.

The result showed that the total energy was calculated as 2,946.57 MJ $da^{-1}$ used for radish production (Table 3). Deep plowing had the highest energy use share followed by irrigation, first watering after transplanting, Second plowing, Sowing seeds, Pan, Spraying, Fertilization-Base and top, Harvest and Packaging energy inputs as 591.42MJ $da^{-1}$, 584.74MJ $da^{-1}$, 356.19MJ $da^{-1}$, 234.05MJ $da^{-1}$, 180.72MJ $da^{-1}$, 121.82MJ $da^{-1}$, 119.33MJ $da^{-1}$ and 1.147MJ $da^{-1}$ of total energy use, respectively. The energy consumption rates, energy efficiency, specific energy, and net energy of radish production are calculated in Table 3. The results revealed that the energy ratio was 1.62. Similarly, the energy ratio (only apple fruit) was 1.51 for apple production in Turkey by Akdemir et al. (2012) [3] and around 1.1 in high-density apple farms in Western US by Reganold et al. (2001) [33] and 1.0 considering only fruit and 2.37 considering fruit and pruning wood as outputs (Strapatsa et al. 2006) [37]. It has not collaborated with the results of Mousavi-avval et al. (2011) and Mousavi-avval et al. (2011a) [22, 21] cultivate soybean (2.29) and canola (3.02) crops for energy ratio. Also, Rafiee et al. (2010) [31] and Ozkan et al. (2005) [25] calculated this value of 2.86 and 5.10 for apples and grapefruits respectively. In our study, energy productivity was 0.62, and energy intensiveness was 2.28 $MJTL^{-1}$. Similarly, Akdemir et al. (2012) [3] stated that the energy efficiency is 0.63 and the energy density is 3.31 $MJTL^{-1}$. Strapatsa et al. (2006) [37] used values for energy productivity of 0.42 kg $MJ^{-1}$ and energy intensity of 2.5. Also, Blanke and Burdick (2005) [4] used values for energy intensity of 2.87 for European and 2.24 for New Zealand's apple production (due to larger yields), but, for flesh fruits, values of 1.2- 2 were reported in Italy (Pellizzi,1992) [27].

In addition, according to research results, the net energy yield was 1,853.43$MJda^{-1}$ and the specific energy was 1.47 MJ $kg^{-1}$. This finding is similar to Akdemir et al. (2012) [3] that the specific energy was 1.59 $MJkg^{-1}$.

Table 3. The energy consumption and Energy input-output relationship for radish

| **Input** | **Total energy equivalent ($MJda^{-1}$)** | **Percentage of total energy input ($MJda^{-1}$) (%)** |
|---|---|---|
| Deep plowing | 636.68 | 21.60 |
| Second Plowing | 356.19 | 12.08 |
| Sowing seeds | 234.05 | 7.94 |
| Pan | 180.72 | 6.10 |
| First watering after transplanting | 584.74 | 19.84 |
| Fertilization-Base | 119.33 | 4.14 |
| Fertilization-Top | 119.33 | 4.04 |
| Irrigation | 591.42 | 20.07 |
| Spraying | 121.82 | 4.13 |
| Harvest | 1.14 | 0.03 |
| Packaging | 1.14 | 0.03 |
| Total energy input (MJ/da) | 2,946.57 | 100.00 |
| Yield (kg/da) | 4,800.00 | – |
| Energy output-input ratio | 1.62 | – |
| Energy productivity($kgMJ^{-1}$) | 0.62 | – |
| Specific energy($MJkg^{-1}$) | 1.47 | – |
| Energy intensiveness ($MJTL^{-1}$) | 2.28 | – |
| Net energy($MJda^{-1}$) | 1,853.43 | – |

Source: Result of survey, 2019.

By increasing the yield of radish production and/or decreasing the energy consumption, especially deep plowing energy, radish production in the research region will be efficient. Estimation of energy input in different modes of energy sources. The sustainability of the energy used in agriculture has dimensions such as social, economic, and ecological as well as non-renewable energy. Direct, indirect, renewable, and non-renewable energy inputs are shown in Table 4. The total energy used contribution of non-renewable energy 41.84% is higher in the radish than in the production of renewable energy 8.17%. The results show that radish production depends on non-renewable energy. Various researchers have figured out greater use of non-renewable energy sources than renewable energy in agricultural area energy consumption (Esengun et al. 2007, Ozkan et al. 2007, Pishgar-Komleh et al., 2012, Yilmaz et al. 2005) [7, 26, 30, 43]. 33.81% more indirect energy input than 16.18% direct energy. This finding is consistent with Pishgar-Komleh et al. (2012) [37] that direct (43%) and indirect (57%) energy contribute to energy intake. In addition, has not collaborated with the results concluded by Kızılaslan, (2009) and Özkan et al. (2004)[14, 24] that direct and indirect energies in agricultural production have almost equal shares. Pellizzi (1992) [27] found that 45-60% of total energy in corn production was in direct form while the contribution of indirect energy was 40-55%.

Table 4. Energy consumption under different energy sources for radish production

| Energy forms | MJda$^{-1}$ | % of total energy input | Inputs |
|---|---|---|---|
| Direct energy | 1,404.90 | 16.18 | Human, diesel, electricity, canal |
| Indirect energy | 2,935.20 | 33.81 | Seeds, fertilizers, chemicals, machinery |
| Renewable energy | 708.16 | 8.17 | Human, seeds, canal |
| Non-renewable energy | 3,631.94 | 41.84 | diesel, electricity, chemicals, fertilizers, machinery |
| **Total** | 8,680.20 | 100.00 | |

Source: Result of survey, 2019

Table 5 revealed the unit cost of production per decare (da) for radish production of which labor cost, fuel cost (traction), and material used with 70.75; 14.41 and 14.84% respectively.

Table 5. Production costs of the product of radish

| Unit cost | Labor | Fuel | Material Used | Total |
|---|---|---|---|---|
| % | 70.75 | 14.41 | 14.84 | 100 |

Source: Survey, 2019.

In our study, the profit rate is 87.82% and we also observe that the production cost and sales price ( $ / ton) of radish are obtained at 21.69 and 40.21 respectively as presented in Table 6. The total sales and total cost in radish production are calculated as 8,266,627.16 and 4,401,252.81 respectively. In addition, we obtained 3,865,374.35 of sales-cost and a profit rate of 87.82% are given in Table 7.

Table 6. Production cost of radish

| Production Cost ( $ /ton) | Sales Price ( $ / ton) | Profit rate (%) |
|---|---|---|
| 21.69 | 40.21 | 87.82 |

Source: Survey, 2019.

Table 7. Product of radish sale and cost

| Total Sales ($) | Total Cost ($) | Sales - Cost | Profit rate (%) |
|---|---|---|---|
| 887.82266627.16 | 4,401,252.81 | 3,865,374.35 | 87.82 |

*1 US $=18.90 TL (March 2023).
Source: Survey, 2019.

## CONCLUSIONS

In this study, energy use patterns in radish production in Osmaniye Province in Turkey were investigated. The total energy used in radish production was 2,946.57 MJda$^{-1}$. While the energy input from the plowing had the largest share in the total energy input, it was followed by irrigation and the first irrigation after planting 16.18% of the energy input used in radish production is direct while 33.81% is indirect energy input. In addition, the share of renewable was (8.17%) and non-renewable (41.84%) energy inputs. The reason for the high consumption of deep plowing is the temporary wear and tear of machinery, especially tractors. The production cost and selling price ( $ / ton) of radish are obtained at 21.69 and 40.21 respectively. We find that the profit rate of agricultural income was 87.82% while that of energy was 61.38%. By focusing on price, the price of inputs may change but the energy remains constant. The equipment that the cost is not high that can be useful for the production of radish in the study area will be effective.

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