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Sustainable Energy Practices in Cabbage Production in Niğde Province of Türkiye

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A B S T R A C T

Examining the inputs to agricultural production and analyzing their energy implications is a crucial method for assessing environmental challenges and promoting sustainability. The agricultural industry utilizes energy in diverse ways, both directly and indirectly, encompassing pesticides, electricity, fertilizers, farm equipment, irrigation systems, fuel, and human labor. This research focused on assessing the agricultural inputs utilized in cabbage cultivation within one of the most cabbage cultivated area in Türkiye, gathering data on these inputs, and identifying the energy efficiency associated with this production process. In the study, information on the overall energy inputs was gathered from numerous white cabbage producers in the Niğde province using the face-to-face survey method, a quantitative research approach. According to the results of the research, the total energy input equivalent in cabbage production was determined as 4407.87 MJ da^{-1} and the total output value was determined as 6348.60 MJ da^{-1}. The energy productivity was determined as 1.20 and the energy balance as 1940.73 MJ da^{-1}. According to the findings, with 33.4% of diesel oil, 23.81% of fertilizer, and 23.06% of machinery make up the majority of this production's inputs. Also, 89.19% of the total energy inputs in cabbage production determined as non-renewable and 10.79% of them as renewable energy inputs. In conclusion, the inputs are efficiently utilized in cabbage production within the Niğde province of Türkiye.

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Introduction

The increasing world population and the consequent need for food have led to new searches for food security and sustainable agricultural production. Together with these, situations such as the reduction of agricultural production areas, labour shortages and climate change have led to the determination of increasing energy use, which is one of the most important inputs, as an option in solving the endangered food security (Ozkan, 2004a; 2004b; 2004c).

At the same time, producers have increased their energy inputs excessively in line with their plans to achieve maximum income/profit, but on the other hand, this situation raises energy security and environmental sustainability problems. Thus, the actions undertaken to sustain agricultural production, coupled with the rising energy inputs, present challenges to both human and environmental well-being, particularly impacting agricultural sustainability. (Gundogmus et al., 2006). Hence, it's essential to quantify the energy inputs for products cultivated in agriculture and devise production strategies that address excessive energy consumption in this context. Consequently, strategies can be formulated to promote the efficient utilization of energy, a fundamental requirement for sustainable agriculture (Saglam et al., 2018). In this study and statement, it was stated that three main objectives should be achieved in the context of "determining the efficiency of energy use". These are increasing the contribution of energy input values to the sustainability of production in the fields of human and machine labour, use of fertilizers and pesticides, and diesel fuel consumption, increasing the efficiency of energy use by determining production inputs for the sustainability and increasing of production and the conservation efficiency of resources by minimizing the factors and practices that may pose a threat to human and environmental health.

For the sustainability of production, it is necessary to assign the production inputs and calculate the efficiency in energy use. In determining the input usage related to the products grown, human labor (h), machine labor (h), amount of fertilizer and pesticide used (kg), amount of irrigation water (m^3), and fuel quantity (L) can used as reference. Thus, the evaluation of energy use data in line with the studies carried out on the basis of the products grown and the regions where the production is made can create essential potential in terms of solving current and future problems.

Niğde province has been a significant agricultural production center throughout history. Currently, agricultural land occupies 35.4% of the total land area within the province. Also, Niğde ranks second in terms of cabbage production, significantly contributing to the region's agricultural output and subsequently generating employment opportunities at a notable rate (Gorur et al., 2016). Niğde province produced 131.205 tons of white cabbage from 18.530 da of cultivated area in 2022 according to TÜİK (2022). Hence, analyzing energy consumption in this significant cabbage-producing region is crucial, aiming to implement enhancements based on defined principles.

The aim of this study is to calculate the efficiency analysis of energy use in cabbage production in Niğde province by determining the inputs such as human labor (h), machine labor (h), amount of fertilizer and pesticide used (kg), amount of irrigation water (m^3), and fuel quantity (L) and outputs through a questionnaire made to 100 cabbage producers.

Material and Method

Ethics Statement

"Efficiency Analysis of Energy Use in Cabbage Cultivation in Niğde Province" project was already approved by Niğde Ömer Halisdemir University Ethics Committee in Türkiye with a file number 16/05/2023-359112. Upon obtaining ethics approval, the study was conducted to cabbage producers in Niğde province of Türkiye.

Experimental Design

This study includes the determination of the energy inputs in the production of cabbage in Niğde province, as well as the determination and evaluation of the efficiency of use of energy resources or inputs. The main material of the study is face-to-face interviews, which is one of the quantitative research methods, and provided from the cabbage producers in Niğde province. The data gathered from the survey conducted with one hundred cabbage producers.

Energy Equivalents

In every agricultural production system, the minimum energy inputs could be listed as power including human and machinery with power supply such as diesel, oil, and electricity etc., main fertilizers such as macro- and micro-nutrients, pesticides, irrigation and seeds. The energy inputs for cabbage production included in the study consist of; human labour, machinery, fertilizers, pesticides, irrigation water, and diesel fuel parameters that are demonstrated in Table 1. The total amount of energy input was found together with the sum of the amounts of these inputs, which corresponds to total energy equivalent, used in production individually per hectare (ha).

Initially, data on input quantities were collected from white cabbage producers to ascertain the energy equivalents of these inputs, utilizing various studies that provided energy equivalent coefficients for the analysis. Consequently, the overall energy input was calculated by multiplying the quantities of inputs utilized by their respective energy equivalents. Subsequently, the output data was computed and expressed in MJ ha^{-1}. Additionally, the following formulas were employed to assess energy utilization efficiency (Burnett et al., 1982), energy productivity (Mandal et al., 2002), specific energy amounts in cabbage production (Mittal et al., 1988) and energy balance (Singh et al., 1997).

$$\text{Specific Energy} = \frac{\text{Total energy input (MJ } da^{-1})}{\text{Yield (kg } da^{-1})} \quad (1)$$

$$\text{Energy use efficiency} = \frac{\text{Energy output (MJ } da^{-1})}{\text{Energy input (MJ } da^{-1})} \quad (2)$$

$$\text{Energy productivity} = \frac{\text{Yield } (kg\ da^{-1})}{\text{Energy input } (MJ\ da^{-1})} \quad (3)$$

$$\text{Energy balance} = EO(\ MJ\ da^{-1}) - EI\ (Mj\ da^{-1}) \quad (4)$$

EO: Energy output; EI: Energy input

Table 1. Energy equivalents of inputs in cabbage production.

Parameters	Unit	Energy Equivalent (MJ da^{-1})	Reference
Power			
Human labour	h	1.96	Yaldiz et al., 1993
Machinery	h	62.7	Singh et al., 2002
Fertilizers			
Nitrogen (N)	kg	60.60	Singh et al., 2002
Phosphorus (P_2O_5)	kg	11.96	Singh et al., 2002
Potassium (K_2O)	kg	6.7	Singh et al., 2002
Pesticides			
Fungicides	kg	92	Helsel, 1992
Herbicides	kg	238	Helsel, 1992
Irrigation			
Irrigation water	m^3	0.63	Yaldiz et al., 1993
Diesel oil	L	56.31	Singh et al., 2002
Seed	kg	1.2	Singh et al., 2002

For a cabbage producer, the energy inputs and outputs of agricultural production are the factors that determine the environmental effects of vegetable production and energy efficiency (Risoud, 2000). The energy efficiency of a productive system is measured as the energy output divided by the energy input. Energy use efficiency can be increased by reducing the input processes of machine power, fertilizers, pesticides, and fuel known as non-renewable energy sources, and human labour known as renewable energy sources or increased output processes (Swanton et al., 1996; Yilmaz et al., 2005).

Results and Discussion

Demographic Information of Cabbage Farmers

It was determined that the average age of the cabbage producers interviewed within the scope of the research in Niğde was 48.17. The 89% of these producers are men and the remaining 11% are women. The educational level distribution of the producers participating in the research is 42% primary school, 19% secondary school, 20% high school, and 15% university graduate.

The average number of family members in the examined enterprises is 5.45 and 65% reside in the village, 28% in the district and 7% in the province. In addition, 77% have social security. The experience period of cabbage producers is 20.42 years on average and 71% of them own agricultural field. Average income from agricultural activities is 428.410 TL (Turkish Lira). While sixty eight of the surveyed farmers are only engaged in agriculture, the thirty two farmers are engaged in agricultural activities as well as non-agricultural activities such as civil servants, shopkeepers, self-employed and retired teachers.

Of the farmers engaged in agricultural activities, 38% never 51% sometimes 11% listens to the radio constantly, 4% never 45% sometimes 51% watches television constantly, 45% never 46% sometimes 49% constantly reads newspapers.

The 17% of the farmers engaged in agricultural activities took part in the governing bodies of the village (such as the Headman, the Council of Elders), and the 54% of them are members of an organization, association, or farmer's organization such as Agricultural Credit Cooperative, Irrigation Cooperative, Village Development Cooperative, Irrigation Union, Chamber of Agriculture, Beet Producers Cooperative, etc. The 61% of the producers participating in the research partially and 20% completely believe that these organizations are for the benefit of the farmer. The 82% of the farmers engaged in agricultural activities implement some of the innovations you have heard or learned, and 9% apply all the innovations you have heard or learned and the fifty-two farmers of them learned from other farmers in the village and forty farmers from the members of the agricultural organization. The 86% of producers get information from agricultural organizations or experts about irrigation methods and amounts, 81% about fertilization and spraying or application time of plant regulators.

The 26% of the producers go to the surrounding villages once a week, 32% 2-3 times a week and 26% 1-2 times a month; 22% go once a week 34% 2-3 times a week 30% go to the district centre 1-2 times a month; 18% go once a week 24% 2-3 times a week 37% go to the city centre 1-2 times a month; 12% go once a week 15% 2-3 times a week 22% go to the going to big cities 1-2 times a month. In addition, if 40% of the producers have a problem, 22% once a week, 36%, 1-2 times a month, agricultural engineers, veterinarians, etc. meeting with technical staff. The 85% of the farmer engaged in agricultural activities consult others on agricultural issues. Mostly the exchanges of ideas are agricultural consultants, agricultural organizations, and farmers.

The 76% of the farmers engaged in agricultural activities have knowledge of good agricultural practices and 34% produce cabbage barley wheat corn with good agricultural practices and the 66% of them are producing without good agricultural practices (Figure 1.). They stated that the reason for this was that they obtained more products with conventional agriculture and that they did not find it necessary. In addition, 49% of the producers say that good agricultural practices are necessary, while 51% do not find good agricultural practices necessary (Figure 1). Because until now, 41% of them have not participated in any activity or training related to good agricultural practices (Figure 1). Most of the farmers do not receive good agricultural support because they do not have detailed information about good agricultural practices and the amount of support is low. When the farmer's field availability is examined, the size of the average cabbage field is 9.9 da and the number of cabbages in per da varies between 1500 and 2000 in dense planting and between 1000 and 1500 in sparse planting.

Energy Inputs and Outputs in Cabbage Production

The 70% of the producers participating in the research have heard of the concept of energy use efficiency and 66% have heard of the efficiency analysis of energy use in cabbage production (Figure 2).

The data of the human labour (h) machinery (h), fertilizers (kg), pesticide (kg), irrigation water (m^3) and diesel oil (L) energy inputs which are included in the cabbage cultivation period are obtained from the cabbage producing farmers in the Niğde region. The use of these inputs in this cabbage production process and their total energy equivalents and shared percentages are indicated (Table 2).

According to the results made in the research area, the human labour input per da during the cabbage production process was determined as 97 hours. Also, the quantity of fertilizers applied per da was determined as 13.72 kg for N, 8.83 kg for P and 16.75 kg for K, and it was reported that a total of 39.3 kg of fertilizer was applied during the cabbage cultivation period. Furthermore, 1.20 kg of fungicide, 1.19 kg of herbicide, and a total of 2.39 kg of pesticides were used to deal with pests. The use of machinery, which is one of the most contributing inputs of this production, was determined as 16.21 hours per da and the use of diesel oil is 26.16 L. The amount of irrigation water included in this production process has been converted from ton units to m^3 and it has been obtained that there is 453.07 m^3 of water input per da (Table 2).

According to the data obtained from the region, it was determined that the total energy input in the production process was 4407.87 MJ da^{-1}.

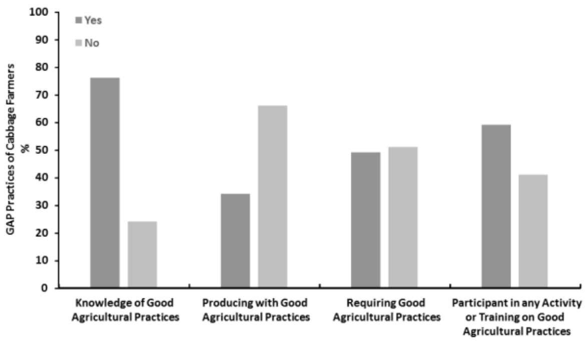

Figure 1. General knowledge of cabbage producers about good agricultural practices (n=100)

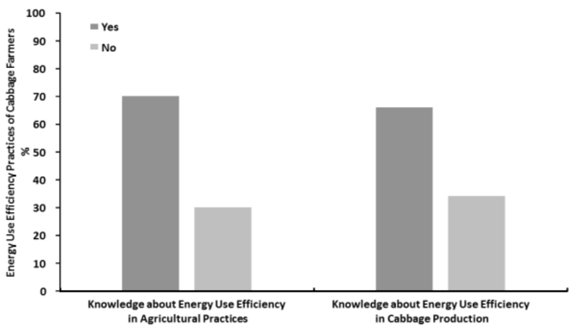

Figure 2. Adequacy of the farmers about the concept of energy use efficiency in Niğde and cabbage production (n=100)

Table 2. Energy equivalent, energy input, total energy equivalent, and percentage of total energy input of cabbage production. Data were represented the mean (n=100)

Parameters	Unit	Energy equivalent (MJ da^{-1})	Energy Input (per da)	Total energy equivalent (MJ da^{-1})	Percentage of total energy input (%)
Input					
Human labour	h	1.96	97	190.12	4.32
Machinery	h	62.7	16.21	1016.37	23.07
Fertilizers					
Nitrogen (N)	kg	60.60	13.72	831.43	18.86
Phosphorus (P_2O_5)	kg	11.96	8.83	105.60	2.40
Potassium (K_2O)	kg	6.7	16.75	112.23	2.55
Pesticides					
Fungicides	kg	92	1.20	110.4	2.5
Herbicides	kg	238	1.19	283.22	6.42
Irrigation water	m^3	0.63	453.07	285.43	6.48
Diesel oil	L	56.31	26.16	1473.07	33.4
Total Input				4407.87	100
Output					
Yield	kg	1.2	5290.5	6348.60	
Energy Use efficiency				1.44	
Energy productivity	kg MJ^{-1}			1.20	
Energy balance	MJ da^{-1}			1940.73	
Specific energy	MJ kg^{-1}			0.83	

The largest share in these energy inputs includes the use of diesel oil, fertilizer, and machinery, and they constituted approximately 80% of the total production with 33.4%, 23.81% and 23.07%, respectively. The remaining 20% consists of 8.92% pesticides, 6.48% irrigation water, and 4.32% human labour. The energy equivalent of all inputs in total was determined as 4407.87 MJ da^{-1} and total energy output 6348.60 MJ da^{-1} (Table 2).

To measure how efficiently energy is used during the cabbage cultivation process, energy use efficiency was determined. A result greater than 1 in energy use efficiency indicates that energy use in production is effective, and this efficiency increases with the increase in the number. In this framework, as a result of the ratio of the total energy output to the total energy input, the energy use efficiency was greater than 1 (as 1.44 MJ da^{-1}) for the cabbage production in this region (Table 2).

According to the data obtained, energy productivity was determined in order to find the amount of cabbage obtained per energy use. Thus, according to the ratio of total yield output to total input energy equivalent, energy productivity was determined as 1.20 kg MJ^{-1}. Furthermore, in order to determine the amount of energy required for the production of one kg of cabbage, the specific energy amount was calculated and obtained as approximately 0.83 MJ kg^{-1} (Table 2).

Human labour input was indicated as 4.32% and irrigation water input 6.48% of total energy input. The ratio of renewable energy, which includes the energy input of human labour and irrigation water, in the total energy is quite low and found as 10.8%. Diesel oil input was calculated as 33.4%, fertilizer input was 23.81%, pesticides input was 8.92%, and machinery input was 23.07% of total energy input. 89.2% of the energy input used for cabbage production process is consist of non-renewable energy, and this energy resources are limited and are likely to run out (Table 3).

Upon examination of the existing literature pertaining to sustainable energy practices in cabbage production, it was noted that a dearth of directly pertinent studies existed.

Table 3. Energy consumption according to different energy forms in cabbage production. Data were represented the mean (n=100)

Energy Form	Amount (MJ da^{-1})	Percentage of Total Energy (%)	List of inputs
Renewable-energy	475.55	10.80	Human labour, irrigation water.
Non-renewable energy	3932.32	89.20	Diesel oil, fertilizer, pesticides, machinery.
Total energy amount	4407.87	100.00	

In response to this deficiency, alternative sources of information were sought, with a focus on comparable research conducted on other vegetables. Through an exhaustive review of studies related to similar crops, key patterns and findings were identified, which could be extrapolated to inform our investigation into sustainable energy practices within cabbage production in Niğde Province of Türkiye. By employing this comparative methodology, our aim was to illuminate potential implications and avenues for advancing sustainability within the cabbage farming sector, notwithstanding the absence of specific literature dedicated to this particular crop. Through the dissemination of our findings, we endeavor to contribute to the broader discourse on sustainable agricultural practices, providing actionable insights for practitioners and policymakers alike. A study was conducted on energy input, output, and expense analysis in open field tomato production in Tokat province. Data were collected through questionnaires from 98 different producers. Tomato cultivation in open field it has been calculated that the total energy input value is 96957.36 MJ ha^{-1}. Of the total energy input, 12,531.55 MJ ha^{-1} comes from labour and 6792.68 MJ ha^{-1} from machinery. In tomato production, the energy input/output ratio was calculated as 0.80 and the energy productivity value as 1.00 kg MJ ha^{-1}. Another result was that 24% of the total energy consumption was come from renewable energy sources (Esengun et al., 2007). In greenhouses in Antalya region energy input analyses were made for some vegetables grown. According to the results of the research, the total energy input was calculated as 134771.3 MJ ha^{-1} in cucumber, 127324.9 MJ ha^{-1} in tomato, 98,682.5 MJ ha^{-1} in eggplant and 80253.4 MJ ha^{-1} in pepper. The energy input/output ratio was calculated as 0.76 in cucumber, 1.26 in tomato, 0.61 in eggplant and 0.99 in pepper (Ozkan et al., 2004c). A study was conducted for late field production for three consecutive years (2010-2012) on the analysis of energy input, output, and expense in two varieties of broccoli (IZK Iskra and Coronado F1) production at the Maritsa Vegetable Crops Research Institute (MVCRI) in Plovdiv, Bulgaria. Total energy input was calculated as 3570.31 MJ da^{-1} in Coronado F1 variety and 3511.68 MJ da^{-1} in IZK Iskra variety. Total energy output was calculated as 2674.10 MJ da^{-1} in Coronado F1 variety and 3235.10 MJ da-^{1} in IZK Iskra variety. Energy input/output ratio was calculated as 0.75 and 0.92 for Coronado F1 and IZK Iskra varieties, respectively. The shares of renewable energy for Coronado F1 and IZK Iskra varieties production were almost equal and were up to 64.20% (Mihov et al., 2013).

An energy assessment was conducted for the late production of Kyose 17, Balkan, Pazardzhishko podobreno and Pazard-zhishko cherveno varieties in order to determine the energy density of farm systems for traditional and organic head cabbage production at the Maritsa Vegetable Crops Research Institute (MVCRI) in Plovdiv, Bulgaria. In conventional production, nitrogen, phosphorus, and potassium fertilizers are used to give 743.82 MJ da^{-1}, 275.08 MJ da^{-1}, 163.48 MJ da^{-1} total energy input, respectively. Also 142.80 MJ da^{-1} herbicide, 50.60 MJ da^{-1} fungicides and 123.76 MJ da^{-1} insecticides were applied in conventional production. Total energy input was calculated as 4864.81 MJ da^{-1}, 4810.96 MJ da^{-1}, 4793.15 MJ da^{-1}, 4584.86 MJ da^{-1} for Kyose, 17 Balkan, Pazardzhishko podobreno, Pazardzhishko cherveno varieties, respectively in conventional production. And also, total energy output was calculated as 5288.00 MJ da^{-1}, 5064.00 MJ da^{-1}, 4952.00 MJ da^{-1}, 3984.00 MJ da^{-1} for Kyose, 17 Balkan, Pazardzhishko podobreno, Pazardzhishko cherveno varieties, respectively. The use of diesel, which is one of the most contributing inputs to this production, was determined as 19.3 L average per decrease in used varieties. The amount of irrigation water included in this production process is specified as 450.0 m^3 of water input per decare in all varieties. Energy input and output ratio was calculated as 1.09, 1.05, 1.03 and 0.87 in Kyose, 17 Balkan, Pazardzhishko podobreno, Pazardzhishko cherveno varieties, respectively (Mihov et al., 2012). The values obtained as a result of the research Mihov et al. (2012) are similar to the values obtained in the literature. The most important results were determined that the total energy input in the production process was 4407.87 MJ da^{-1}, the total energy output was 6348.60 MJ da^{-1}, energy use efficiency was 1.44 MJ da^{-1}, and energy productivity was 1.20 kg MJ^{-1}.

Conclusion

In conclusion, our analysis of energy utilization in cabbage production within Niğde province has shed light on its efficient practices, as evidenced by the balanced metrics of 1940.73 MJ da^{-1} and an energy productivity rate of 1.20 kg MJ^{-1}. While Niğde demonstrates commendable efficiency in its agricultural energy use, there's an opportunity for further optimization. To sustain this positive trajectory, stakeholders should consider implementing advanced agricultural technologies, optimizing resource allocation strategies, and promoting energy-efficient farming practices. By embracing these measures, Niğde can not only enhance its agricultural output but also reinforce its commitment to sustainable and resilient farming systems for the future.

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References

Burnett, M. (1982). Energy analysis of three agro-eco systems. In *Paper presented at second International Conference on Basic Techniques in Ecological Farming held during* (pp. 1-5).

Esengun, K., Erdal, G., Gündüz, O., & Erdal, H. (2007). An economic analysis and energy use in stake-tomato production in Tokat province of Turkey. *Renewable energy*, *32*(11), 1873-1881.

Gorur, A., Dogan, S., Caliskan, M, E., Unal, E. and Turkmen, H. S. (2016). Nigde İl Gelişme Planı (NİGEP). http://www.nigde.gov.tr/kurumlar/nigde.gov.tr/HaberResimler/OCAK%202017/nigep1.pdf

Gündogmus, E., & Bayramoglu, Z. (2006). Energy input use on organic farming: a comparative analysis on organic versus conventional farms in Turkey. *Journal of Agronomy*, 5 (1), 16-22.

Helsel, Z. R. (1992). Energy and alternatives for fertilizer and pesticide use. *Energy in farm production*, *6*, 177-201.

Mandal, K. G., Saha, K. P., Ghosh, P. K., Hati, K. M., & Bandyopadhyay, K. K. (2002). Bioenergy and economic analysis of soybean-based crop production systems in central India. *Biomass and bioenergy*, *23*(5), 337-345.

Mihov, M., Antonova, G., & Mihov, K. (2013). Energy assessment of new broccoli variety. *Bulgarian Journal of Agricultural Science*, *19*(5), 1056-1060.

Mihov, M., Antonova, G., Masheva, S., & Yankova, V. (2012). Energy assessment of conventional and organic production of head cabbage. *Bulgarian Journal of Agricultural Science*, 18(3), 320-324.

Mittal, J. P. (1988). Research manual on energy requirements in agricultural sector. All India Co-ordinated Research... Agricultural Sector. New Delhi: ICAR. p.20 –3.

Ozkan, B., Akcaoz, H., & Fert, C. (2004a). Energy input–output analysis in Turkish agriculture. *Renewable energy*, *29*(1), 39-51.

Ozkan, B., Akcaoz, H., & Karadeniz, F. (2004b). Energy requirement and economic analysis of citrus production in Turkey. *Energy Conversion and Management*, *45*(11-12), 1821-1830.

Ozkan, B., Kurklu, A., & Akcaoz, H. (2004c). An input–output energy analysis in greenhouse vegetable production: a case study for Antalya region of Turkey. *Biomass and Bioenergy*, *26*(1), 89-95.

Risoud, B. (2000, May). Energy efficiency of various French farming systems: questions to sustainability. In *International Conference Sustainable energy: new challenges for agriculture and implications for land use* (pp. 18-20). Wageningen: Wageningen University..

Saglam, C. and Cetin, N. (2018). Organik ve Geleneksel Bahçe Tarımında Enerji Kullanım Etkinliğinin Belirlenmesi. *Bahçe,* 47 (Special issue 2) 84–90.

Singh, H., Mishra, D., & Nahar, N. M. (2002). Energy use pattern in production agriculture of a typical village in arid zone, India—part I. *Energy conversion and management*, *43*(16), 2275-2286.

Singh, M. K., Pal, S. K., Thakur, R., & Verma, U. N. (1997). Energy input-output relationship of cropping systems. *The Indian Journal of Agricultural Sciences*, *67*(6).

Swanton, C. J., Murphy, S. D., Hume, D. J., & Clements, D. R. (1996). Recent improvements in the energy efficiency of agriculture: case studies from Ontario, Canada. *Agricultural Systems*, *52*(4), 399-418.

TÜİK, (2022). Turkish Statistical Institute. https://www.tuik.gov.tr/, (Access date: 7.12.2023)

Yaldız, O., Öztürk, H. H., Zeren, Y., & Başçetinçelik, A. (1993). Energy usage in production of field crops in Turkey. 5th International Congress on Mechanization and Energy Use in Agriculture, 527-536. https://www.cabidigitallibrary.org/doi/full/10.5555/19942400018

Yilmaz, I., Akcaoz, H., & Ozkan, B. (2005). An analysis of energy use and input costs for cotton production in Turkey. *Renewable Energy*, *30*(2), 145-155.