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ENERGY CONSUMPTION AND GREENHOUSE GAS EMISSIONS FROM IRRIGATION APPLICATIONS AT DIFFERENT HEIGHTS IN CORN AND SUGARBEET PRODUCTION IN KUZOVA REGION OF TURKEY

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Abstract

The main method for providing water for irrigation purposes is the transmission of water between the water source and the field for irrigation. This movement of water requires an energy. Therefore, the effects of irrigation applications at different heights on energy consumption and greenhouse gas emissions (GHGs) in Kuzova region in Elazıg province of Turkey were evaluated in this study. While energy consumption for sugar beet irrigation is 3.46 GJ /ha at a height of 30 m, it reaches 10.26 GJ/ha for irrigation of more than 150 m. However, while fuel consumption for corn irrigation is 3.71 L GJ/ha at a height of 30 m, it reaches 12.73 GJ/ha for irrigation of more than 150 m. While the GHG emissions from sugar beet irrigation is 256.27 kgCO_2-eq/ha at a height of 30 m, it reaches 759.66 kgCO_2-eq/ha for irrigation of more than 150 m. However, while the GHG emissions from corn irrigation is 274.58 kgCO_2-eq/ha at a height of 30 m, it reaches 942.71 kgCO_2-eq/ha for irrigation of more than 150 m.

Key words: *corn, sugar beet, irrigation, energy, GHG emissions*

INTRODUCTION

As with all living things, plants need water in order to survive. The required water is taken from the soil mainly with plant roots. Some of the water taken up by the plants is used in the production of various compounds and mainly for photosynthesis. A very important part is given to the atmosphere by sweating. The amount of water remaining in the plant and used in various physiological processes is too small to be taken into consideration besides the amount of water supplied to the atmosphere by transpiration process. Therefore, irrigation is a very important input in agriculture and it is one of the most important factors that increase the yield. When the amount of water that the plant needs cannot be met by rainfall, the application of it to the soil with different irrigation methods and systems is called irrigation. Irrigation crop yield; plant, soil, irrigation method used, depending on climate and production conditions can increase between 1 and 5 times [6]. However, over-applied irrigation reduces productivity; Soil drainage, salinity and aridity (sodium) can cause problems.

Agriculture currently uses 11% of the world's land surface, and irrigated agriculture uses 70% of all water withdrawals on a global scale [9]. Rainfed agriculture is the predominant agricultural production system around the world, and its current productivity is, on average, little more than half the potential obtainable under optimal agricultural management. Water scarcity and decreasing availability of water for agriculture constrain irrigated production overall, and particularly in the most hydrological stressed areas and countries. As many key food production systems depend on groundwater, declining aquifer levels and the depletion of non-renewable groundwater put local and global food production at risk. Increasing food production is not, on its own, sufficient to achieve food security and eradicate hunger. Hunger can persist in the midst of adequate national and global food supplies. Efforts to promote food production must be complemented by policies that enhance household access to food, either by creating employment and income opportunities or by establishing effective safety net programmes.

Water, energy and food are inextricably linked. Water is an input for producing agricultural goods in the fields and along the entire agrifood supply chain. Energy is required to produce and distribute water and food: to pump water from groundwater or surface water sources, to power tractors and irrigation machinery, and to process and transport agricultural goods. Agriculture is currently the largest user of water at the global level, accounting for 70% of total withdrawal [2]. The food production and supply chain accounts for about 30% of total global energy consumption [3].

There are many synergies and trade-offs between water and energy use and food production. Using water to irrigate crops might promote food production but it can also reduce river flows and hydropower potential. Growing bioenergy crops under irrigated agriculture can increase overall water withdrawals and jeopardize food security. Converting surface irrigation into high efficiency pressurized irrigation may save water but may also result in higher energy use. Recognizing these synergies and balancing these trade-offs is central to jointly ensuring water, energy and food security. Estimates suggest that global food production will need to increase by as much as 60% by 2050 to meet demand [4, 5]. Achieving such a dramatic increase is a formidable challenge.

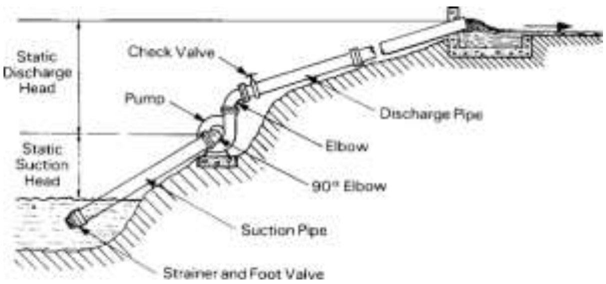
The main method for providing water for irrigation purposes is the transmission of water between the water source and the field for irrigation. This movement of water requires energy. Therefore, the effects of irrigation applications at different heights on energy consumption and greenhouse gas emissions (GHGs) in Kuzova region in Elazıg province of Turkey were evaluated in this study.

Pumping facility for irrigation

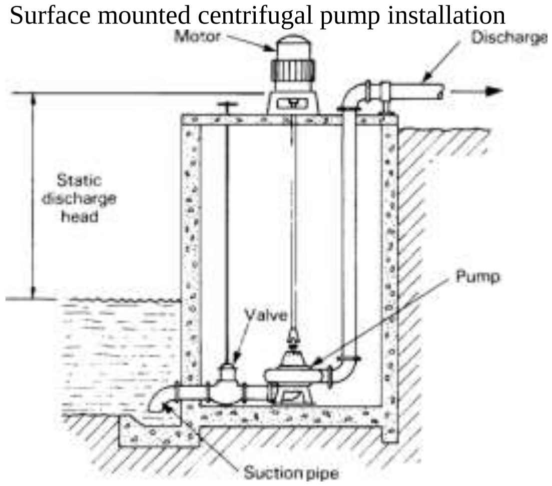
The millions hectares that are irrigated by groundwater account for most of the energy used for irrigation. As groundwater irrigation, in general, provides greater flexibility than other types in responding to fluctuating water demands, its relative importance is likely to increase in the future. Groundwater for irrigation can be withdrawn from both shallow and deep aquifers. Where extraction rates from shallow groundwater stores exceed recharge rates, water abstracted from greater depths, pumped by energy intensive electric pumps, will likely become more important. Avoiding groundwater depletion, through sustainable groundwater management, can lead to long term cost and energy savings [10].

Pumping facility

The main method for providing water for irrigation purposes is the transmission of water between the water source and the field for irrigation. This movement of water requires energy. All mechanical tools and materials used for the transmission of water between the source and the field form the pumping plant (Fig. 1).



a) Surface mounted centrifugal pump installation



b) Below-surface centrifugal pump installation

Fig.1. Pump installations

Source: [6]

The design, selection, installation, operation and maintenance of the pumping plant include important engineering issues. The main

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purpose here is to provide the irrigation water required by the plant to be irrigated in time, with sufficient amount, with minimum energy and operating expense.

The water source can be an underground or surface source. Various methods are applied to distribute the water in the field and deliver it to the plants. In surface irrigation method, irrigation water is carried by open channels and gravity is used for flow. The water taken from the channels is delivered to the plants by means of pans or furrows. In the sprinkler irrigation method, water is transported to the plants with the energy provided from the pumping plant and disintegrated into drops in special nozzles and delivered to the field. Therefore, the sprinkler irrigation method requires more energy for the pumping plant. This should be taken into consideration in the project.

In the pumping plant, the pump delivers the energy it receives from a force machine to the water. With this energy, water is transported through the pipelines from the water source to the field. Pumping facilities include building materials, electrical equipment, piping systems, pumps, valves and motors. As a unit consisting of a pumping station, a power machine and a construction machine, irrigation water needs to be able to meet the required amount of time and with the lowest energy consumption. This issue has become even more important, especially in today's rapidly increasing energy costs. In a pumping station, the pumps account for 8% of the construction cost and 60% of the operating cost [8].

The following factors should be considered for energy efficient pumping facilities [1]:

-Suitability of the pump characteristics to the pumping facility.

-Variability of water flow rate.

-Suitability of pipelines to the facility.

-Compatibility of pump and system with variable speed pumping in variable flow pumping facilities.

-Compliance of pump specifications with standards.

The entire facility can be considered as an energy exchange unit. Accordingly, the energy supplied by the fuel or electric current is first converted into mechanical energy in the motor and then transmitted to the water by the pump. If there is a power transmission arrangement between the motor and the pump, the transmission efficiency of this arrangement must also be considered.

In this case, the total system efficiency should be high in a pump station that can achieve the above purpose. In other words, it is necessary to provide more hydraulic energy for the unit fuel or electricity consumed. For this purpose, the following four basic issues should be well known and applied when planning a pumping facility [11]:

(i)Planning of pipeline

(ii)Selection of pump

(iii)Selection of force source

(iv)Operation and maintenance of the facility

Heights in pumping facility

The task of the pump in the pumping facility is to transmit the energy required to transfer water from one medium (water source) to another (area to be irrigated).

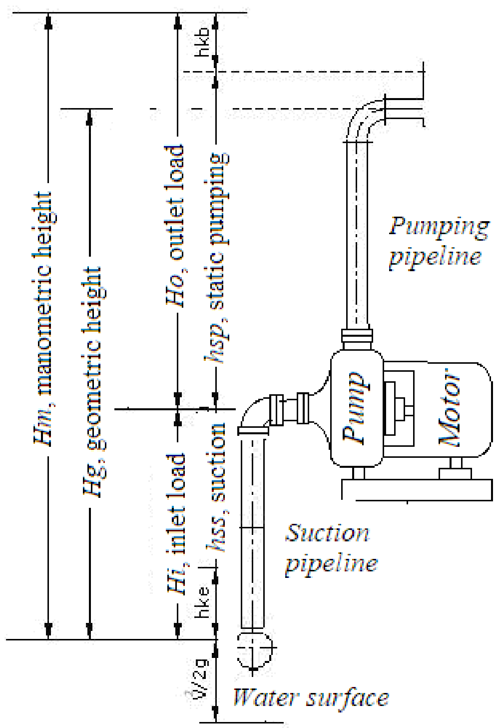

Fig. 2. Heights at the pumping facility
Source: Own drawing.

With this energy, water rises from one position to the other, and defeats the resistances in the pipelines in which it moves.

The pump receives mechanical energy from a source of force and transmits this energy to the water through its moving units. It refers to a height term as the energy given to the unit weight of water during this change, and is often referred to as the meter water column (mSS). The term *load* or *height* is the vertical distance between the free surface of the water body elementally and any reference plane. This value indicates the ability to do energy or work. The operating heights of the pump in a pumping facility are shown in Fig. 2.
If the position difference between the water source and the highest point at which the water is raised (*Hg*, geometric height) is the energy requirement (*hk*) caused by the flow of water in the pipelines between these two points, the total energy for the movement of the water is defined as follows [7]:

$$H_m = H_g + h_k \quad \text{.............................}(1)$$

The manometric height (*Hm*) of the pumping facility depends on the difference in elevation between the water source and the area to be irrigated, and the length, diameter, type and auxiliary pipe parts used in the pipelines to be used for water transmission.
In other words, *Hm* is determined by the pipelines of the pumping facility. *Hm* is the height used to determine the energy required to transmit water from the level of suction to the highest level at which it is pumped.

MATERIALS AND METHODS

Study area description

Elazıg province is located in the Upper Euphrates Section in the southwest of the Eastern Anatolia Region in Turkey. The province consists of 11 districts, 537 villages and 709 hamlet settlements together with the central district.
Uluova is one of the most important plains. The plain part of the plain is bare. Kuzova is a very long plain and very efficient. The crop in the region is abundant and varied. In addition, Murudu, Zahini, Adedi, Karayazı, Baskil and Hanpınar Plains are known as the main plains.
In terms of agricultural structure; 29% of the province's surface area is located on an area of 264,123 hectares. In 176,717 hectares of this area, fallow farming, 68,531 hectares of irrigated agriculture and 18,875 hectares of vineyard-garden are cultivated.
In Elazıg province, a different and characteristic climate is observed. The geographical location and morphological characteristics of the province have been the most important factor in the emergence of this favorable situation. In the province, continental climate is dominant, winters are cold and rainy and summers are hot and dry. However, the reservoirs formed around the province show partial deviations in the climate.
Since the structure of the soil is medium or permeable soil throughout the province, no significant irrigation problem has been encountered. Considering the water and soil characteristics, it is possible to say that it has a soil and water structure suitable for agriculture.
Products grown in Elazıg vary widely. In dry agricultural areas, cereals are predominant. Wheat, barley, chickpeas and lentils are the main. In recent years, many high places and plain ova-irrigated irrigation in cereals grown in dry agriculture has been replaced by industrial plants grown in irrigated agriculture. Cotton, tobacco and sugar beet are the major ones. The belt, Keban and Baskil districts have gained importance. In addition, melon, watermelon and other fruits and vegetables are grown by the local people.
Kuzova is a long plain on both sides of the Cip (Sarini) river, which flows into the North and joins the Murat River. The north of the plain, which is 900-1,000 meters above the sea extending to the north, has an area of approximately 110 km^2. Kuzova showing a stepped situation is an efficient plain. Alluvial soils are found only in the valley of Sarini Stream. This river is not enough to water the water is low. For this reason, Cip Dam was constructed for irrigation purposes and many wells were drilled. Kuzova is divided into two parts by a series of hills consisting of Tilki Tepe Karsıdag-Kurt Tepe-Kızıldag and Kekliktepe in the south and extending in the

southwest and northeast direction and resembling a ridge. The northern part of the plain, which corresponds to Kuzova, which covers a much wider area, is in a syncline. The eastern part of the Kuzova basin consists of a volcanic terrain. Here, the olivine basalts, which had emerged from an east-west direction, formed a series of lapses towards the north in the direction of the slope of the plain.

Kuzova irrigation project consists of two parts. Elazıg Kuzova pumping irrigation project consists of two parts: Ziyarettepe and Meseli. The water to be taken from Keban Dam Lake is 290 meters with the water pump project, and the Meseli Pumping Irrigation Project is 279 meters in total and 219 thousand 90 decares of agricultural land is planned to be irrigated.

Calculation methodology of GHG emissions in irrigation applications

Diesel-based energy inputs = Diesel used × Lower heating value

Diesel-based CO_2 emissions = L/ha × 0.0371 GJ/L

Diesel-based CO_2 emissions = GJ/ha

Diesel-based CO_2 emissions = Diesel used × Lower heating value × Emission factor

Diesel-based CO_2 emissions = L/ha × 0.0371 GJ/L × 74.01 $kgCO_2$/GJ

Diesel-based CO_2 emissions = $kgCO_2$/ha

RESULTS AND DISCUSSIONS

Fuel consumption for irrigation

The fuel (diesel) consumption at different heights for irrigation of corn and sugar beet productions are given in Fig. 3.

While fuel consumption for sugar beet irrigation is 93.33 L/ha at a height of 30 m, it reaches 276.66 L/ha for irrigation of more than 150 m.

However, while fuel consumption for corn irrigation is 100 L per hectares at a height of 30 m, it reaches 343.33 L/ha for irrigation of more than 150 m.

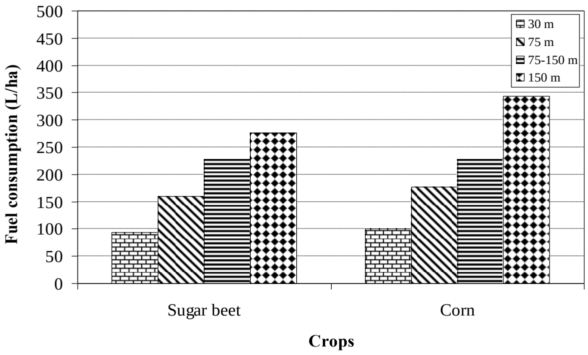

Fig. 3. The fuel consumption for irrigation
Source: Own calculation.

Energy consumption for irrigation

The energy consumption at different heights for irrigation of corn and sugar beet productions are given in Figure 4. While energy consumption for sugar beet irrigation is 3.46 GJ /ha at a height of 30 m, it reaches 10.26 GJ/ha for irrigation of more than 150 m. However, while fuel consumption for corn irrigation is 3.71 L GJ/ha at a height of 30 m, it reaches 12.73 GJ/ha for irrigation of more than 150 m.

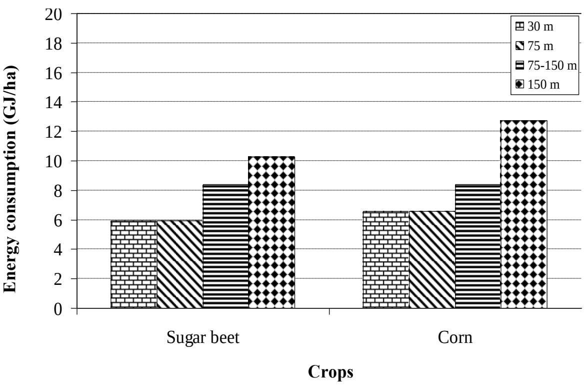

Fig. 4. The energy consumption for irrigation
Source: Own calculation.

GHG emissions from irrigation applications

Figure 5 gives the levels of GHG emissions per hectares from irrigation applications depending on the heights. While the GHG emissions from sugar beet irrigation is 256.27 $kgCO_2$-eq/ha at a height of 30 m, it reaches 759.66 $kgCO_2$-eq/ha for irrigation of more than 150 m. However, while the GHG emissions from corn irrigation is 274.58 $kgCO_2$-eq/ha at a height of 30 m, it reaches 942.71 $kgCO_2$-eq/ha for irrigation of more than 150 m.

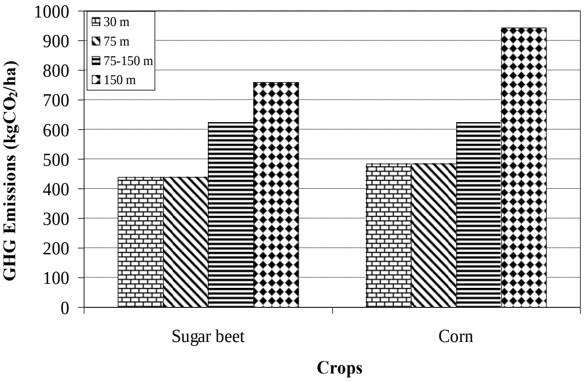

Fig. 5. GHG emissions for irrigation applications
Source: Own calculation.

CONCLUSIONS

Mechanical irrigation systems should be designed to use water as efficiently as possible. Crops often take up only half of the irrigation water applied, so there is clearly potential to improve water use efficiency, which would also result in less demand for electricity or diesel fuel for pumping. However, much controversy and debate exist about the engineering concept of 'water use efficiency. It is widely accepted that, while irrigation losses appear high, a large part of these 'losses' return to the river basin in the form of return flow or aquifer recharge, although the water quality of the return flows may have been altered. Measures to increase water use efficiencies upstream, while maintaining existing levels of withdrawal, will increase the productive efficiency of water use, but at the same time, may deprive downstream users who depend on return flow in rivers or groundwater aquifers fed from these returns.

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