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DETERMINATION OF MECHANIZATION PROPERTIES of MODERN GREENHOUSE FARMS: THE CASE of AZERBAIJAN

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Annotation

Azerbaijan is one of the countries that develop in the field of greenhouse cultivation. In this study, it was aimed to determine the agricultural structure and mechanization characteristics of modern greenhouse farms operating in Azerbaijan. The data used in the study were obtained by questionnaire. In the survey, a total of 14 business officials operating in Azerbaijan were interviewed face-to-face.

According to the findings of the research, the average greenhouse area size in the farms is 64.7 ha. It is seen that the installation of greenhouses has increased after the 2010s. Except for one farm greenhouses, the installation of all greenhouses was carried out by Turkish companies. In all greenhouses (100%), heating, irrigation-fertilization and ventilation units are controlled by automation systems. 50% of the greenhouses have fogging system and 57% have thermal curtains. The share of greenhouses with a CO2 fertilization system is 7%. In 64% of the farms, the cultural transactioncarts are electric motor and battery powered. In all farms, spraying operations are carried out with hydraulic sprayers. In greenhouses, there are approximately 60 units/ha of electric motors per unit area. The electric motor power value is approximately 54 kW/ha. The number of manually operated machines is about 2.5 units/ha. It was determined that tractors were used only in two farms. There are approximately 62.4 machines/ha per unit area in greenhouses and the total engine power value increases to approximately 55 kW/ha.

Keywords: Modern Horticulture, Mechanization Level, Greenhouse Mechanization, Azerbaijan

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Introduction

In farms, technical, economic, geographical and geographical and climatic features, etc. depending on the features, mechanization means are used to different levels. Mechanization practices contribute to the timely completion of processes, effective use of inputs, improvement of working conditions, and reduction of the need for human labor, allowing for more efficient production in agricultural areas [1]. Mechanization has played a key role in all developments that provide efficiency in the agricultural production of developed countries. In today's competitive global environment, this role will

undoubtedly continue with increasing importance. Especially in the production branches where intensive mechanization applications are seen, the share of mechanization in total operating expenses is increasing. For this reason, the importance of careful mechanization investments and good management during production is increasing. Therefore, it is essential to use mechanization tools effectively, accurately, efficiently and sustainably. For mechanization investments to be made in a planned and appropriate manner for the region, it is necessary to know the agricultural structure and mechanization characteristics of the region [2]. Several methods are used to assess the development and status of agricultural mechanization in a country or region, such as level, indices and grade. The level of mechanization can be determined in terms of engine power per unit area (kW/ha), number of tractors/1000 ha, ha/tractor, mechanical power/total power, and equipment weight/tractor [3].

The most important indicators that define the level of agricultural mechanization of a country or region are criteria such as the status of power resources, power levels, development over the years, relationship with agricultural equipment, and the density of mechanization tools in the unit agricultural area. In order to objectively discuss the mechanization status of the regions that differ in terms of agricultural structure, it is useful to compare these criteria according to the regions. For this reason, many studies have been carried out at the regional and national level for the determination of agricultural mechanization characteristics in the world.

Hakhiyev and Şeflek (2023) determined the level of agricultural mechanization for crop production farms in Azerbaijan. In the ever-evolving Azerbaijani agriculture, the size of the power per unit area is calculated as 1.23 kW/ha, and the area per tractor is 45 ha/tractor [4]. In India, the value of 0.007 kW/ha in 1960 increased to 1.03 kW/ha in 2014 with the replacement of animal force source in agricultural production. This level is projected to increase to 3.74 kW/ha in 2032-2033 [5]. Mechanization level indicators for Brazil were reported as 2.53 kW/ha and 103.9 ha/tractor [6]. For the European Union countries where the use of technology in agriculture is more intense, the mechanization indicators calculated in different units are determined as 6 kW/ha, 11.30 ha/tractor, 89 tractors/1,000 ha, 10 machines/tractors, 12 machine-tons/tractors. Turkey is one of the countries where the increase in the use of machinery in agriculture continues. Aybek et al., (2021) reported that the mechanization level indicators across Turkey were 2.22 kW/ha, 58.66 tractors/1000 ha, 4.78 machines/tractors and 17.05 ha/tractors, respectively [7].

When the studies are evaluated, it is seen that the indicators of the level of mechanization differ according to countries and regions depending on different factors such as the level of use of mechanical power sources instead of human and animal labor, the diversity of agricultural production and regional characteristics. However, it can be said that the stated values in undeveloped and developing regions tend to increase.

In many Asian countries, electric motors and independent diesel/gas engines are used in machines such as water pumps, product processing machines, threshing machines, cleaners, etc., apart from tractors. This ratio of the power size of these engines used in China, Pakistan, India, Bangladesh and Cambodia to the total power size in the farms was reported as 22.31%, 25.94%, 43.1% (26.8% + 16.3%), 43.78% (41.09% + 2.69%) and 46.44%, respectively [8]. Kaba and Çanakcı (2020) compared the mechanization characteristics of traditional and modern cattle farms. Tractor power per unit area is calculated as 0.20 kW/ha and 1.21 kW/ha in traditional and modern farms, respectively. With these values, it is understood that 8.9% of the total power in traditional farms and 34.2% in modern farms consists of electric motor power. The electric motor power per cattle in the same farms was determined as 0.18 kW/cattle and 0.22 kW/cattle, respectively [9].

However, another area where electric motors are used is greenhouse cultivation. In greenhouses, there are mechanization applications in both air conditioning and cultural processes. In a study conducted by Çanakcı and Akıncı (2004) in Antalya, Turkey's greenhouse center, tractor power per unit area in traditional greenhouse farms was determined as 10.83 kW/ha, and electric and stand-alone diesel engine power was determined as 7.05 kW/ha [10].

Greenhouse cultivation; it differs from other agricultural production branches with its characteristics such as being carried out under a structure, requiring higher human labor, capital, etc. Greenhouse cultivation can be divided into two classes, traditional and modern, considering cultivation techniques and greenhouse structures. Modern greenhouses; it can be defined as greenhouses where technological products are used in building and cover materials and air conditioning systems, modern applications are included in cultivation techniques and indoor conditions are controlled by automation systems. The practice of cultivation in soilless culture in the specified greenhouses is widespread.

Since more income is obtained from the unit area in greenhouse cultivation, this production branch is carried out in many countries where climate and infrastructure characteristics are suitable. One of the countries where greenhouse cultivation is developing is Azerbaijan, where there are suitable climatic conditions and a wide variety of products. The area of greenhouses in Azerbaijan has been increasing in recent years, and the total area in 2016 has increased from 761 ha in 2011 to 2165 ha. a study conducted in the Shamkir region, it was determined that the ventilation, heating and cooling systems in greenhouses that are not modern are not sufficient [11]. At the same time, there is an increase in modern greenhouses in the country and the presence of modern greenhouses is estimated at 750 ha [12].

When the studies to determine the level of mechanization in literature are examined, it is seen that the number of studies on greenhouse cultivation in agricultural production remains limited. But one of the areas where intensive electric motor power is used in agriculture is modern greenhouse cultivation. Knowing the mechanization features in greenhouse cultivation is important in terms of both investment and operating expenses. In this study, it is aimed to determine the agricultural mechanization characteristics of modern greenhouse farms in Azerbaijan, which has been developing in recent years.

Materials and methods

The data used in the study were obtained by questionnaire. The survey was carried out by face-to-face interviews with business officials. In determining the number of farms to be surveyed, the rule of 1% of the main population was taken into account and a survey was conducted with a total of 14 farms [13]. Considering the total modern greenhouse area of 89.7 ha in the surveyed farms, it is seen that 12% of the total areas in the country are within the scope of the survey. The centers where the surveyed farms are located are given in Figure 1.

The survey was carried out infarms operating in five different regions. These cities are Baku, Sumqait, Salyan, Jalilabad and Masalli. In addition to the general characteristics of the farms, the questionnaire included questions about the mechanization infrastructure related to aquaculture such as air conditioning systems such as ventilation, heating, fogging, etc., irrigation-fertilization systems, sprayers, cultural processing carts and tractors. Calculations and evaluations of the data obtained in the survey study were made in MS Excel spreadsheet program.

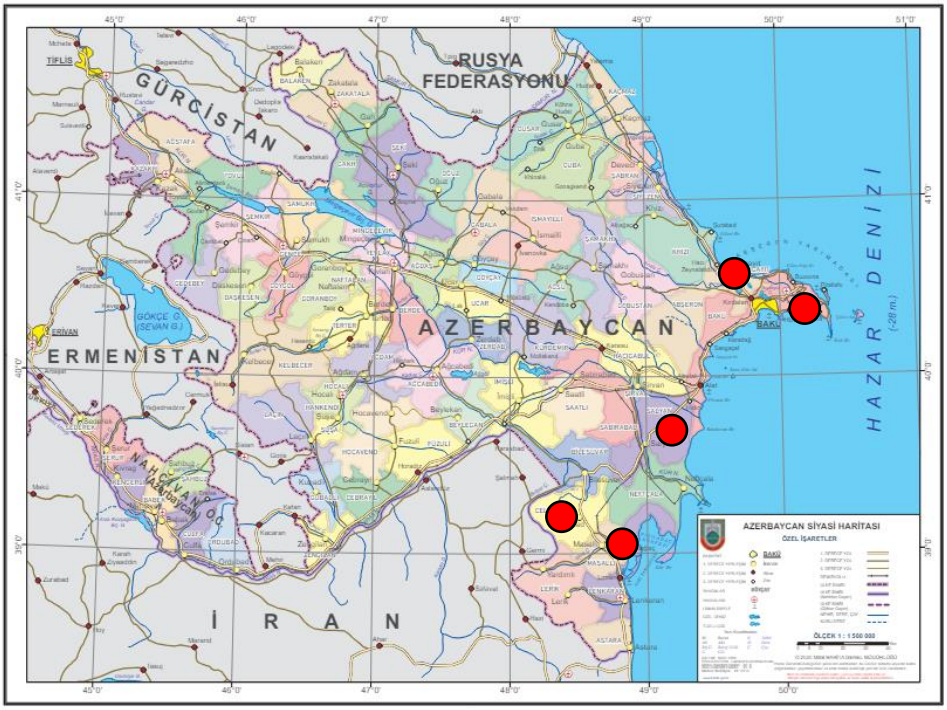

Figure 1. Map of Azerbaijan and surveyed locations [14]

Results and discussion

3.1 General Properties

The total greenhouse areas in the farms surveyed is 89.7 ha. The average business size was calculated as 6.4±1.0. The establishment direction of modern greenhouses is in the north-south direction and galvanized steel is used as the construction material. Cocopit is preferred as the growing medium of plants. The water needs of the grown plants are met from different sources such as wells, artificial ponds, mains water and canal water according to the characteristics of the greenhouse location. Most of its greenhouses have been established by companies based in Turkey. Some other general characteristics of farms are given in Table 1.

It is known that greenhouse areas in Azerbaijan have been on an upward trend, especially after the 2000s. According to Table 1, it is seen that modern greenhouses in the surveyed farms have started to be established since 2009. 28.6% (4 units) of the farms were established in 2013. There are 1-4 greenhouses on each farm, and the total number of greenhouses on 14 farms is 31.The average greenhouse size was calculated as 28.9±3.0. In modern greenhouses, mainly tomato cultivation is carried out.

Considering the cover material, it has been determined that only one farm prefers glass material. It has been determined that all other farms use polyethylene (PE) material, which is more economical, in their gothic roofed greenhouses. A total of 6 farms preferred to use PE material on the roof, as well as PC material, which is a longer-lasting hard plastic cover material, on the side surfaces. In greenhouses, side heights are 4.0-6.0 m, roof heights are 6.0-7.7 m.

In addition to electric motors, a limited number of thermal motors are used as a power source in machinery and systems used in agricultural processes. In addition to air conditioning operations, the use of electric motors is intense in vehicles used to activate irrigation, fertilization, spraying and transportation processes. However, it is seen that the machines used in transportation operations are moved by human labor. The use of tractors is very limited.

Table 1. Some general characteristics of modern greenhouse farms

Farm No	Year of Foundation	Number of Greenhouse	Cover Material	Side Height	Roof Height	Crop

		Total Area, ha		Roof	Side Sur-face	m	m	
1	2010	30.2	3	Glass	Glass	5.0	7.7	Tomato
2	2013	9.8	3	PE	PC	5.0	7.7	Tomato
3	2010	3.7	3	PE	PE	5.0	7.7	Tomato
4	2011	6.3	3	PE	PE	5.0	7.7	Tomato
5	2012	4.0	2	PE	PE	5.0	7.7	Tomato
6	2013	4.0	2	PE	PE	5.0	7.7	Tomato
7	2013	4.0	2	PE	PE	5.0	7.7	Tomato
8	2013	4.0	2	PE	PE	5.0	7.7	Tomato
9	2015	2.5	1	PE	PC	4.5	7.5	Tomato
10	2015	3.0	1	PE	PC	4.0	6.0	Tomato
11	2012	2.0	1	PE	PE	5.0	7.0	Strawberry
12	2009	10.0	4	PE	PC	5.0	7.7	Tomato
13	2014	4.0	2	PE	PC	4.0	6.0	Tomato
14	2012	2.1	2	PE	PC	5.0	7.7	Cucumber
Total	**-**	**89.7**	**31**	**-**	**-**	**-**	**-**	**-**

3.2. Machinery/Systems in Greenhouses and Their Features

3.2.1. Ventilation systems

Ventilation in greenhouses is mostly carried out by natural ventilation systems. Each roof has a single or double ventilation opening. The movement of the mechanisms that open and close the windows, which are mostly in pairs, is given by electric motors with switch adjustment and gear. The power of the roof motors is 0.37 kW, and one motor is capable of controlling windows up to 120 m long. In double-wing greenhouses, there are two motors on each roof, and in single-wing greenhouses, there is one motor on each roof. The values of the ventilation systems used in greenhouses are given in Table 2.

Table 2. Ventilation system equipment and electric motors in the greenhouses

Ventilation system	Number of Farm	Mechanization Level			
	unit	unit/farm	unit/ha	kW/farm	kW/ha
Roof Ventilation Openings	13	127.36	19.88	47.12	7.36
Circulation Fans	13	193.43	30.19	71.57	11.17
Exhaust Fans	1	1.79	0.28	3.57	0.56
Total	-	**322.58**	**50.35**	**122.26**	**19.09**

It was determined that circulation fans were used to activate the indoor air of the greenhouse. For this purpose, fans with an electric motor of 0.33-0.55 kW are used at intervals of 30-40 m. Fan capacities are usually 7400 ^{m3}/h. In addition, it was determined that there was a forced/mechanical ventilation system in only one farms. For this purpose, it is used with a movable exhaust fan from an electric motor with a power of 2 kW. As can be seen in Table 2, the total number of electric motors per farm and unit area in ventilation systems is 322.58 units/farm and 50.35 units/ha, respectively. The unit power indicators of the electric motors were calculated as 122.26 kW/farm and 19.09 kW/ha, respectively.

3.2.2. Heating systems

Hot water heating systems are used in greenhouses. Natural gas is preferred as an energy source in heating systems due to its cost-effectiveness, easy accessibility and ease of maintenance in Azerbaijani conditions. In the selection of greenhouse heating boilers in the region, a capacity value of 200 kcal/h is taken into account for each m2 greenhouse area. It was determined that the boiler capacities used in the greenhouses of the surveyed farms varied between 2500000-7500000 kcal/m2. The power ratings of the electric motors used in the burners, main supply and sectors are 7.5 kW, 5 kW and 1.5 kW, respectively.

In the system, water is heated by natural gas-fired heating boilers and delivered to pipes placed between rows. The heat energy is transmitted to the indoor environment of the greenhouse and the cooled water is sent back to the boiler by pumps. Hot water pipes also serve as rails for wheeled vehicles used during cultural transactions. During the operation of the system, the sectors are divided into different sectors according to the size of the greenhouse, and the control of each sector can be done separately with the help of sensors and automation systems. This system is available in all greenhouses examined. In addition, it was determined that a plant heating system was used in addition to the existing hot water pipes in only one farm. The values of heating systems and electric motors used in greenhouses are given in Table 3.

Table 3. Heating system units and electric motors in greenhouses

Heating System	Number of Farm	Mechanization Level			
	unit	unit/farm	unit	unit/farm	unit
Heater/Burner	14	2.64	0.41	26.86	4.19
Main Feed Pumps	14	2.64	0.41	18.43	2.88
Sectors	14	9.57	1.49	24.43	3.81
Plant Heating	1	1.71	0.27	3.43	0.54
Total	**-**	**16.56**	**2.58**	**73.15**	**11.42**

In the surveyed greenhouse farms, the total number of electric motors used in heating systems was determined as 16.56 units/farm, and the number of machines per unit area was determined as 2.58 units/ha. Electric motor power values per operation and per unit area were calculated as 73.15 kW/operation and 11.43 kW/ha, respectively (Table 3).

3.2.3. Thermal curtain

In greenhouses, thermal curtain applications are made to reduce the air volume to be heated in the indoor environment of the greenhouse during periods when the outdoor air is cold. With this method, fuel savings are achieved by reducing the heat requirement for the greenhouse. Curtains can also be used for shading during periods when the air temperature is high and the amount of sunlight is high. In thermal curtain applications, electric motors are used to open and close the curtains on steel ropes. For this purpose, electric motors with a power of 0.55 kW are generally used.

It was determined that thermal curtain systems were used in 57.1% (8 units) of the surveyed farms. Considering the general research, the number of electric motors per farm is 7.29 units/farm, and the number of motors per unit area is 1.14 units/ha. When the electric motor powers are taken into account, the power values per farm and unit area are 4.01 kW/operation and 0.63 kW/ha, respectively.

3.2.4. Fogging system

Fogging systems are used to increase the humidity level inside the greenhouse or to reduce the temperature level inside the greenhouse to a certain extent by cooling. For this purpose, water droplets are sprayed at high pressure (90-120 bar) and approximately 0.25 micron in size at the upper points in the greenhouse. This system can also be used for liquid spraying applications. The power of electric motors used for pressurized water can be up to 22 kW. Table 4 shows the values of the electric motors in the fogging systems detected in the greenhouses in the research area.

Table4. Fogging systems and electric motors used in greenhouses

Fogging System	Number of Farm	Mechanization Level			
	unit	unit/farm	unit/ha	kW/farm	kW/ha
Main Distribution	7	5.1	0.8	61.6	9.6
Intermediate Feeding	1	0.4	0.1	4.3	0.7
Total	**-**	**5.57**	**0.87**	**65.86**	**10.28**

It was determined that half of the surveyed farms had fogging systems (Table 4). The number of unit electric motors used in fogging systems was determined as 5.57 kW/farm and 0.87 units/ha. Unit engine power values are 65.86 kW/farm and 10.28 kW/ha. Considering the values, it is noteworthy that high-power engines used to provide high pressure raise the unit indicators.

3.2.5. Fertigation system

Fertigation systems are used in greenhouses where irrigation and fertilization processes can be done together. Irrigation and fertilization programs are controlled by automation systems. The basic units of the system are the manure mixing unit and the main distribution pumps. Other units may vary according to features such as water source, water quality, etc. The power sizes of the motors of the main distribution pumps vary between 3.5-11.0 kW. The power size of the feed motors is 2.5 kW. Electric motors with a power of 1 kW in fertilizer injection systems, 0.38 kW in pneumatic systems and 37 kW in osmosis systems are used. The numerical values of the units and electric motors used in irrigation systems are given in Table 5.

Table 5. Irrigation fertilization system units and electric motors used in greenhouses

Fertigation System	Number of Farm	Mechanization Level			
	unit	unit/farm	unit/ha	kW/farm	kW/ha
Fertilizer Mixing	14	2.71	0.4	6.14	0.96
Main Distribution	14	1.86	0.3	16.68	2.60
Feeding	8	1.71	0.3	11.25	1.76
Osmosis	3	0.71	0.1	18.64	2.91
Pneumatic Mixing	1	0.43	0.1	0.16	0.03
Total	**-**	**7.42**	**1.16**	**52.87**	**8.26**

In addition to the main distribution and fertilizer mixing pump units, there are 8 feeding units in the farm, osmosis in 3 farm and pneumatic mixing units in one plant. Considering the electric motors used in the irrigation and fertilization system, the mechanization indicators per farm and unit area are calculated as 7.42 units/farm, 1.16 units/ha, 52.87 kW/operation and 8.26 kW/ha, respectively (Table 5).

3.2.6. CO_2Fertilization system

CO_2 levels are around 300-600 ppm in outdoor conditions [15]. Due to its positive effect on yield increase and plant development, CO_2 supplementation by artificial means to increase the CO_2 level in greenhouses is called CO_2 fertilization. Despite its positive effects, it is not widely used in greenhouses due to investment costs and operation, etc. It has been determined that there is only one CO_2 fertilization system in the research region. Greenhouse CO_2 is distributed through holes drilled on a pipe under the gutter growing media platform. Considering the research region in general, the number of

electric motors per farm and per unit area was determined as 0.64 units/farm and 0.07 units/ha, respectively. Power level indicators per unit area were calculated as 1.29 kW/farm and 0.20 kW/ha.

3.2.6. Machines used for spraying, transport and cultural transactions

In the spraying operations carried out during the development period in greenhouses, movable horticulutre sprayers driven by electric motors are used. Tank capacities are 1000 lt or 2000 lt and these sprayers have engines with 5 kW and 7.5 kW respectively.

Trolleys that can move on rails that act as hot water pipes are widely used for cultural processes such as pruning, stringing, harvesting etc., which are carried out in modern greenhouses. Carts can be powered by manual or electric motors. It was determined that a total of 9 (64.3%) farms had brushed or brushless electric motor and battery cultural processing carts. The power sizes of the electric motors in the cars are at the level of 0.35-0.38 kW. It has been determined that manual cars are used in a total of 4 farms.

It was determined that 6 farms (42.9%) in the study region used electric motor and battery forklifts. Forklifts are used in greenhouse transportation operations during and after the season. Engine power sizes used in forklifts are at the level of 11.5-14 kW. It has been determined that pallet trucks are used in the operations for lifting and transporting products and materials in all farms. In addition, agricultural trailers pulled by tractors were found in two surveyed farms. Table 6 shows the values obtained for the machines used in spraying, transportation and other cultural operations.

Table 6. Distribution of machines used in spraying, transportation and other cultural operations

Machinery	Number of Farm	Mechanization Level			
	unit	unit/farm	unit/ha	kW/farm	kW/ha
Sprayers	14	1.43	0.22	8.54	1.33
Forklifts	6	0.43	0.07	3.46	0.54
Cultural transaction charts with electric motor	9	21.86	3.41	13.79	2.15
Cultural transaction charts	4	13.79	2.15	-	-
Transpalet	14	2.29	0.36	-	-
Trailer	2	0.14	0.02	-	-
Total	-	**39.80**	**6.21**	**25.79**	**4.02**

The number of machines used for spraying, transportation and other cultural operations in the greenhouses is 39.80 units/farm and 6.21 units/farm. Approximately 60% of these machines have electric motors. Considering the electric motor power used in these machines, the motor power value per operation is 4.02 kW/farm, while this value decreases to 4.02 kW/ha per unit area.

3.2.7. Tractor

The use of tractors as a power source in the modern greenhouses of the research region was found to be very limited. The use of tractors has been determined to be used in greenhouse and out-of-greenhouse transportation in only two farms. The power of the old model tractors used is 51.0 and 51.7 kW. When the values of the tractor are reflected in the research, the number of tractors per farm and unit area is calculated as 0.13 units/farm and 0.02 units/ha, respectively. Unit power level indicators are 7.05 kW/farm and 1.10 kW/ha.

3.3. General Mechanization Level

The calculated values regarding the number of machines/systems, power sources and mechanization level in modern greenhouse farms examined within the scope of the research are given in Table 7.

There is intensive use of electric motors in modern greenhouses, especially in units for air conditioning operations. When all applications are considered, the values of the number of machines per farm and unit area are 400.13 units/farm and 62.42 units/farm, respectively. Power indicators were

calculated as 352.28 kW/farm and 55.01 kW/ha (Table 7). The general characteristics of greenhouse farms are similar to greenhouses in Turkey [16].

Table 7. Number of machines/systems used in modern greenhouses and distribution of power supplies

Machinery/System	Number of Farm	Mechanization Level			
	unit	unit/farm	unit/ha	kW/farm	kW/ha
Electric Motor					
Ventilation	14	322.58	50.35	122.26	19.09
Heating	14	16.56	2.58	73.15	11.42
Thermal Curtain	8	7.29	1.14	4.01	0.63
Fogging	7	5.57	0.87	65.86	10.28
Fertigation	14	7.42	1.16	52.87	8.26
CO_2 Fertilization	1	0.64	0.07	1.29	0.20
Sprayers	14	1.43	0.22	8.54	1.33
Forklift	6	0.43	0.07	3.46	0.54
Cultural Transaction Carts	9	21.86	3.41	13.79	2.15
	Subtotal	383.78	59.87	345.23	53.91
Manuel					
Cultural Transaction Carts	4	13.79	2.15	-	-
Transpalet	14	2.29	0.36	-	-
	Subtotal	16.08	2.51	-	-
Diesel Engine					
Tractor	2	0.13	0.02	7.05	1.10
Trailer	2	0.14	0.02	-	-
	Subtotal	0.27	0.04	7.05	1.10
TOTAL	**14**	**400.13**	**62.42**	**352.28**	**55.01**

It is seen that the indicators of the level of mechanization determined for modern greenhouses are quite high when compared to previous studies conducted for farms engaged in open agriculture in different regions. For example, the calculated power level per unit area is 44.7 times higher than the determined value of 1.23 kW/ha calculated for farms throughout Azerbaijan [4]. It is 3.1 times higher than the total value of 17.88 KW/ha determined for traditional greenhouse farms in the Antalya region, Turkey. Considering only electric motors, it is seen that modern greenhouses have 7.8 times more electric motor power per unit area than traditional greenhouses. The number of electric motors determined in modern greenhouses is 19.2 times higher than in traditional greenhouses [10].

Conclusions

In this study, the agricultural structure and mechanization characteristics of the modern greenhouse processes produced in Azerbaijan were examined.

The average size of the total 14 greenhouse farms examined is 64.7 ha. It is seen that the installation of greenhouses has increased after the 2010s. Except for one farm greenhouses, the installation of all greenhouses was carried out by Turkish companies.

In all greenhouses (100%), heating, irrigation-fertilization and ventilation units are controlled by automation systems. 57% of the greenhouses have a fogging system and 50% have thermal curtains. The share of greenhouses with a $_{CO2}$ fertilization system is 7%. In 64% of enterprises, cultural processing

carts are electric motor and battery-powered. In all enterprises, spraying operations are carried out with hydraulic sprayers.

In greenhouses, there are approximately 60 units/ha of electric motors per unit area. The electric motor power value is approximately 54 kW/ha. The number of manually operated machines is about 2.5 units/ha. The use of thermal engines in the farms is quite limited. It was determined that tractors were used only in two farms.

There are a total of 62.4 machines/ha per unit area in greenhouses. The electric motor power value increases to approximately 55 kW/ha. The greenhouses examined in the research are similar to the greenhouses established in countries such as Turkey. For this reason, it can be said that the values obtained will help the studies to be carried out in similar country conditions.

The power value per unit area (kW/ha) is much higher, especially compared to outdoor cultivation. In modern greenhouses, 7.8 times more electric motors are used than in smaller-scale traditional greenhouses.

Considering the installed power values, it is seen that the number of machines per enterprise in modern greenhouses in Azerbaijan is 400 and the power value is approximately 352 kW. These values cause high installation and operating costs. For this reason, businesses have to be more careful in energy requirement and cost calculations. In this context, it is foreseen that it will be beneficial to carry out more comprehensive studies on energy inputs and cost calculations for application.

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