Palestine Polytechnic University

Design and Building a Nanofarm Machine

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Abstract

This project mainly aims to propose an educational approach to agricultural applications in the field of electronic agriculture control, which has a lot of applications and visions of development around the world, this project would be a very helpful insight to make. The statement of the desired results behind the project is to apply educational experiment involving the planting parsley by Nanofarm. It is a small farm that controls the conditions surrounding the growth of the plant grown within it, by controlling the temperature, humidity, lighting and pH of irrigation water used in it. Also the goal of this project to produce a healthy food crop free of soil diseases, increased transmission of agricultural diseases from the soil to the plant due to poor control of the environmental, air, and human factors surrounding the growth of the plant, and traditional agriculture is facing a major problem in front of these factors. Therefore, agriculture using Nanofarm faced this problem because it keeps the plant inside it and protects it from factors, hydroponics was used inside the Nanofarm, which is produces a disease-free crop, reduces the crop growth period, reduces the use of agricultural pesticides, and saves irrigation water. Nanofarm works by means of a microcontroller that controls all conditions surrounding plant growth within it, the desired results behind this project are that the period of growth of the plant inside the Nanofarm will be reduced, obtaining a healthy product free of diseases and increasing agricultural efficiency.

ملخص

يهدف هذا المشروع بشكل أساسي إلى اقتراح نهج تعليمي للتطبيقات الزراعية في مجال التحكم الإلكتروني في الزراعة، والذي يحتوي على الكثير من التطبيقات ورؤى التنمية حول العالم، وسيكون هذا المشروع بمثابة رؤية مفيدة للغاية. بيان النتائج المرجوة من وراء المشروع هو تطبيق تجربة تعليمية تتضمن زراعة البقدونس بواسطة Nanofarm. هي مزرعة صغيرة تتحكم في الظروف المحيطة بنمو النبات المزروع داخلها، من خلال التحكم في درجة الحرارة والرطوبة والإنارة ودرجة الحموضة لمياه الري المستخدمة فيها. كما يهدف هذا المشروع إلى إنتاج محصول غذاء صحي خالي من أمراض التربة، وزيادة انتقال الأمراض الزراعية من التربة إلى النبات بسبب ضعف السيطرة على العوامل البيئية والهوائية والبشرية المحيطة بنمو النبات، والتقليدية تواجه الزراعة مشكلة كبيرة أمام هذه العوامل. لذلك واجهت الزراعة باستخدام Nanofarm هذه المشكلة لأنها تحافظ على النبات بداخلها وتحميها من العوامل، فقد تم استخدام الزراعة المائية داخل Nanofarm الذي ينتج محصولًا خاليًا من الأمراض، ويقلل من فترة نمو المحصول، ويقلل من استخدام المبيدات الزراعية، ويوفر مياه الري. يعمل Nanofarm عن طريق متحكم يتحكم في جميع الظروف المحيطة بنمو النبات بداخله، والنتائج المرجوة من وراء هذا المشروع هي تقليل فترة نمو النبات داخل Nanofarm والحصول على منتج صحي خالٍ من الأمراض وزيادة الكفاءة الزراعية.

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Chapter 1

1.1Introduction

In recent years, there has been a high development in the field of modern and traditional agriculture due to its great importance in supplying people with food and its importance in the field of economy. It has developed rapidly because of its association with the fast technological development in this world. This is due to the developing in the methods used in agriculture to make it easier for farmers to practice agriculture easily and comfortably and increase the percentage of agricultural crops significantly to meet the needs of people.

The Nanofarm is a small farm that controls the conditions surrounding the growth of the plant grown within it, by controlling the temperature, humidity, lighting, and pH of the irrigation water used in it.

The challenge in this project is the use of microcontrollers to control the conditions surrounding plant growth within the Nanofarm by controlling the irrigation system and controlling the fertilization system, which led us mainly to think and do this project.

1.2Importance and motivation for project

Nanofarm provide high protection for the plants, because it produce a disease-free crop, due to the plant preserved inside the Nanofarm, whereas the plant not exposed to wind, floods and not eaten by insects, and the presence of Nanofarms inside the house is very useful as the plant grown inside it breathe on Carbon Dioxide that comes out of the house and produces oxygen inside the house.

We chose this idea for project because there are not enough agricultural areas when all people, and to provide comfortable for people in the field of home agriculture, due to the ease of use the Nanofarm in homes because they are small in size, and to increase the technological development in agriculture in Palestine.

1.3Chapters overview

Chapter one mainly explains the problem and introduces why it was selected and proposes the methodology of solution, solution which is through that there is a small farm inside each house that meets the needs of the house from crops, while chapter two focuses on the literature review of type the agriculture we have selected for this project, later in chapter three a conceptual design is made with the mention of the used components and the principle of working of Nanofarm. Chapter four explain the calculations needed for the project and electrical design of the project. In addition to the desired conclusions from the project.

1.4Project management

1.4.1Time table

The first three weeks were in selection the project idea, from the fourth week to the eighth week was done Data collection, from the end of the eighth week to the twelfth week was done conceptual design of the project, from the end of the eleventh week to the end of the first semester it was completed documentation.

Table 1: With the following table illustrating the time for the project time (weeks) in first semester:-

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Selection the project idea																
Data collection																
Conceptual design																
Documentation																

The first four weeks were in collecting the components, from the fourth week to the eighth week was done verification and control, from the end of the eighth week to the thirteenth week was done experimental work of the project, from the end of the thirteenth week to the end of the second semester it was completed documentation.

Table 2: With the following table illustrating the time for the project time (weeks) in second semester:-

Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Collecting the components																
Verification and control																
Experimental work																
Documentation																

1.4.2Cost table

The following table shows the parts used in the project and their prices, in order to determine the total cost of the project.

Table 3: With the following table illustrating the budget of the project:-

Cash Flow	**Description**	**Number of units**	**Unit cost [$]**	**Total cost [$]**
Components of the project	Temperature and humidity sensor	1	**10$**	**10$**
	Ph. sensor	1	**18$**	**18$**
	UV lamp	1	**15$**	**15$**
	Heat lamp	1	**1$**	**1$**
	Water pump	1	**5$**	**5$**
	Air pump	1	**5$**	**5$**
	Fan	1	**4$**	**4$**
	LCD screen	1	**11$**	**11$**
	Pipe	3	**3.3$**	**10$**
	Water basin	1	**50$**	**50$**
	External box	1	**50$**	**50$**
	Real time clock	1	**4$**	**4$**
	Electrical valve	2	**16$**	**32$**
	Arduino	1	**20$**	**20$**
Total				**235$**

Chapter 2

System study

2.1 Literature review

2.1.1 Hydroponics

2.1.2 Hydroponic system

2.1.3 Nanofarm

2.1.4 Nanofarm working principle of Replantable company

2.2 questionnaire about Nanofarm

2.3 conclusion

Chapter 2

2.1Literature review

This chapter present the type of agriculture used in the project during the literature review of agriculture methods and the most suitable method for agriculture inside Nanofarm.

2.1.1 Hydroponics

Hydroponics has its derivation from the combining of two Greek words, hydro meaning water and panics meaning labor, i.e., working water **[1].** Hydroponics is a technique used to grow plants in nutrition solutions that provide the plant with all the necessary and nutrient elements needed for its growth. Scientists have been interested in soilless agriculture after many soil-related problems such as diseases, herbs, and increased salinity of the agriculture soil. Then, they started looking for alternative solutions for soil use, and they came to hydroponics. Almost all plants succeed in growing without soil, but there are some plants that grow more aquatic than others, such as different types of lettuce, tomatoes and herbs such as parsley, basil and others **[2].**

Nutrient solution used in Hydroponics consists of concentrated nutrient solution (A_B), Whereas, components of solution elements A are (N.P.K) (Nitrogen N. Phosphorous P. Potassium K) compound fertilizer, magnesium sulfate($MgSo_4$) and microplex, components of solution elements B are Calcium nitrate ($Ca(NO_3)2$), and Iron. The concentrated solution is added to the amount (1 ml A + 1 ml B) for each 1 L water to prepare a diluted solution**.**

Figure 2.1: The nutrient solution (A_B).

The most blatant benefit of hydroponic gardening is the massively increased growth rate of most plants. It's not uncommon for a plant to grow at least 20% faster than soil gardening. On top of that, plants will typically yield at least 25% more than their soil counterparts**[3].**

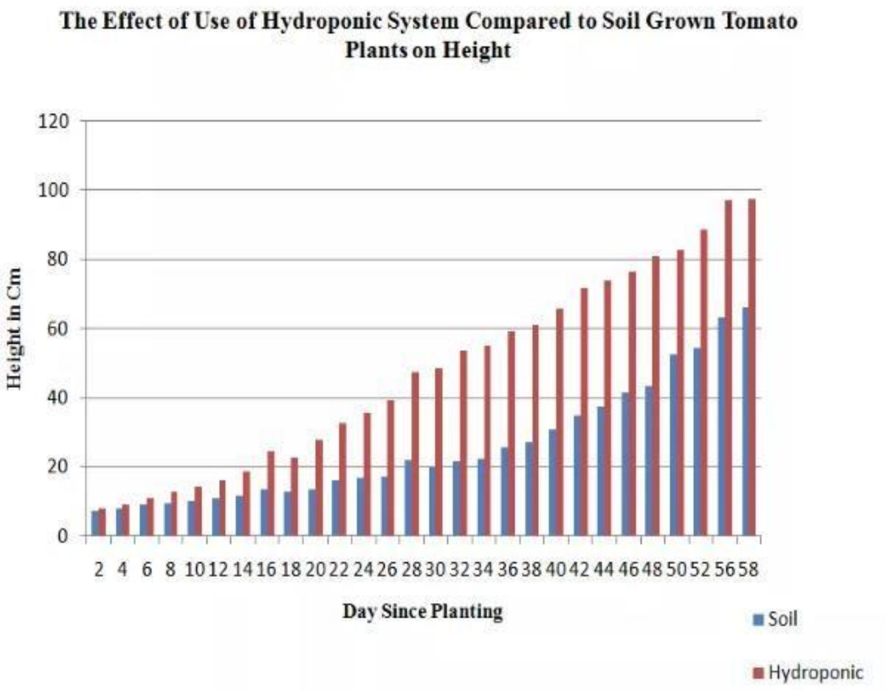

Figure 2.2: A hydroponics vs. soil comparison**[3].**

This figure shows the relationship between the inputs used and the outputs produced by hydroponics**[4].**

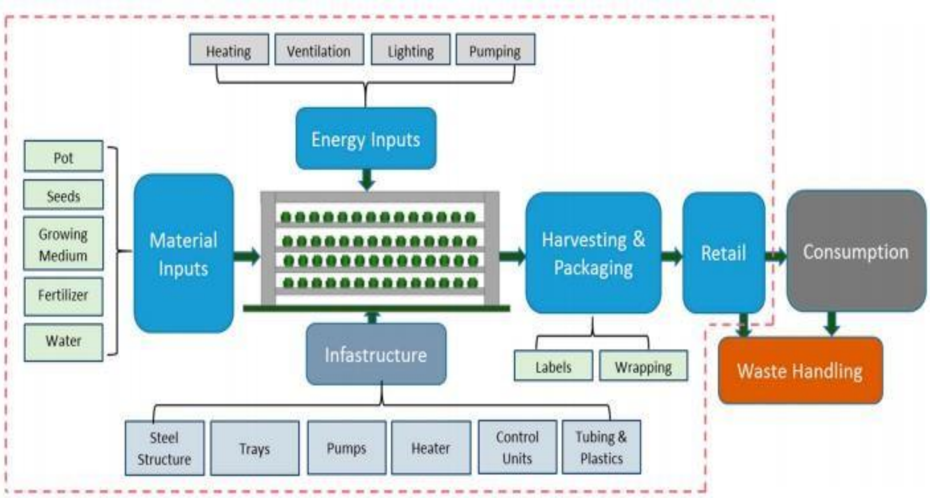

Figure 2.3: Hydroponic system**[4].**

This figure shows the requirements for the production of 60,000 plants annually in hydroponics**[4].**

Main Category	Process/Flow	Amount	Unit	Transport (km)	Lifetime (Years)
Infrastructure	Steel Structure	242	kg	100	30
	LEDs	8640	units	100	15
	Trays (PET)	36	kg	100	15
	Tubing/Other Plastics	10	kg	100	5
	Pumps	2	units	100	10
	Heater and Other Electronics	3	units	100	10
Raw materials	Pot	240	kg	100	-
	Seed	6	kg	100	-
	Growing Medium (Soil)	12,350	kg	50	-
	Nitrogen (N)	10	kg	100	-
	Phosphate (P)	12	kg	100	-
	Potasium (K)	14	kg	100	-
	Paper	449	kg	100	-
	Wrapping Paper	38	kg	50	-
	Label	480	m^2	50	-
	Water	144,890	liters	-	-
Energy Inputs	Lighting	26,490	kWh	-	-
	Ventilation	490	kWh	-	-
	Heating and Electronics	3290	kWh	-	-
	Pumps	2190	kWh	-	-
Outputs	Plants	60,000	plants	-	-
	Distribution	1390	km	-	-

Figure 2.4: Material and energy inputs for the annual production of 60,000 plants[4].

2.1.2 Hydroponic system

The Flood and Drain System: is does not allow watering of plants separately, but all plants are inundated in a balanced way. After being submerged, the system discharges excess water. Very popular with home hydroponic growers for many reasons. Besides how easy they are for anyone to build, you can use almost any materials you have laying around to build them with, so you don't need to spend much money to grow plants hydroponically. Also they can be built to fit in any available space you might have (both indoors or outdoors), and there is no limit to the different and imaginative ways to design them for that space. Along with being inexpensive and easy to build, plants grow very well in flood and drain systems. The flood and drain system works basically like it sounds, by simply flooding the plants root system with nutrient solution**[5].**

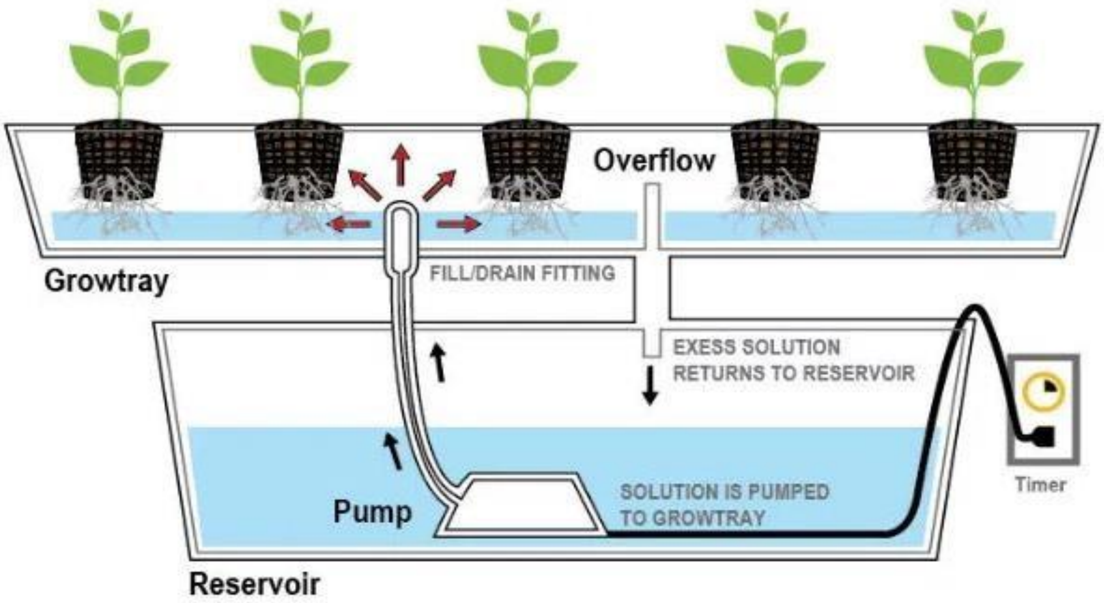

Figure 2.5: The flood and drain system**[5].**

Advantages of Hydroponics:-

1) Crops can be grown where no suitable soil exists or where the soil is contaminated with disease.

2) Labor for tilling, cultivating, fumigating, watering, and other traditional practices is largely eliminated.

3) Maximum yields are possible, making the system economically feasible in high-density and expensive land areas.

4) Conservation of water and nutrients is a feature of all systems. This can lead to a reduction in pollution of land and streams because valuable chemicals need not be lost.

5) Soil borne plant diseases are more readily eradicated in closed systems, which can be totally flooded with an eradicates.

6) Large savings in irrigation water and fertilizers to around 80%.

7) Double production per unit area.

8) The speed of production of agricultural crops.

9) Reduce the use of agricultural pesticides.

2.1.3 Nanofarm

As the name implies, with Nano meaning small, it is a small farm. A company in Atlanta, Georgia came up with the concept of a teeny-tiny farm. The company, Replantable, designed a system with a water tray, a plant pad, some special lighting, and the cabinet to fit everything in. The Nanofarm placed in environmental conditions where the temperature is between 60_80 Fahrenheit, and is not designed for outdoor use. Agriculture within it focusing on salad greens, herbs, and bulb veggies. Because those mini tomato plants take months to grow, produce only a handful of tiny tomatoes **[6].**

Figure 2.6: The Nanofarm by Replantable company**[6].**

At the beginning of their manufacture was used tray agricultural plastic, but it was replaced in stainless steel tray for several reasons **[6]:-**

1) Stronger - nearly impossible to break, and its stiffness makes it easier to carry when full of water.

2) Longer-lasting - stainless cleans up beautifully for many years, while plastic discolors and stains over time.

3) Stainless steel has been used for years in appliances and cookware for its beauty and longevity.

Figure 2.7: The tray agricultural plastic and tray agricultural stainless steel**[6].**

2.1.4 Nanofarm working princeple of Replantable company

The Nanofarm is to plant vegetable in a small and close machine. The seed is placed in the machine and the LED light replaces the sunlight. After that, the growing period of the vegetable is studied. When the vegetable is ready to be eaten, the indicating light is turned on, to remind users to harvest it. The machine is portable and suitable for the traveler with the car to eat fresh vegetable anytime **[7].**

The problem that was solved by the Nanofarm is that the poor automatic controlling of watering and fertilizing causes disease of the plant, such as black spot disease see figure 2.8 , mould leaf disease see figure 2.9 and yellow leaves see figure 2.10. Each disease is caused by different reasons: humidity level and the environment not ventilated causes the black spot disease; For the mould leaf disease is due to the soil moisture level too high at night; and lastly, the lacking of iron in the soil causes the yellow leave disease. Each disease can be prevented, the proper controlling of automatic controlling of watering and fertilizing, and reproducing of friendly environment parameters by Nanofarm**[7].**

Figure 2.8: Black spot disease**[7].**

Figure 2.9: Mould leaf disease**[7].**

Figure 2.10: Yellow leaf disease**[7].**

The original goal of Nanofarm that's designed by Replantable company is to study the tomato growth behavior by using sensors, to use the water efficiently for tomato tree and to control the resource supply to the plant by using the microcontroller. Another objective is to design a home style tomato automation system, to grow the tomato tree in the household environment. This provides a convenient way for people, who live in the city with a busy lifestyle, enables them to eat fresh fruits which planted by themselves**[7].**

Also sunlight is needed to help the plant growth. Therefore, in the Nanofarm research, the sunlight can be replaced with Ultra Violet (UV) light-emitting diode (LED).This figure 2.11 show the absorption of a different wavelength of UV LED, and the highest is 450nm and 650nm. Both wavelengths must be used because each type has a different function. If only used either one, the plant will not stay alive**[7].**

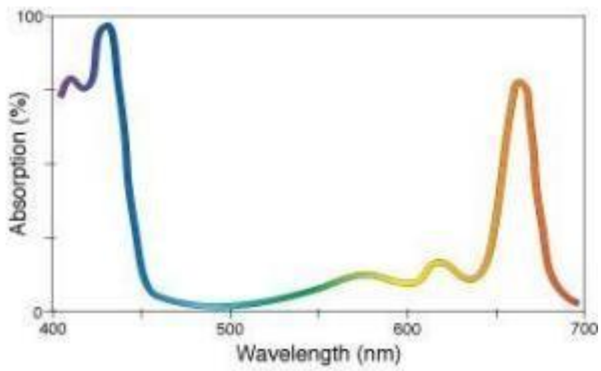

Figure 2.11: The light wavelength absorption for plant**[7].**

In the first of experiment the Nanofarm focus is on the tomato plant. Using Arduino Uno as the microcontroller. Besides an LCD to display the information and all the data that collected from the humidity sensor and real time clock module. Furthermore, the data are stored in micro SD card through the micro SD module. After that, the stored data is used to determine the actions controlling the mini water pump, heater lamp and UV LED lamp. The design of the Nanofarm machine has a rectangle structure, as shown in figure. This is because the tomato plant will be grown vertically**[7].**

Figure 2.12: Nanofarm machine of rectangular shape structure**[7].**

2.2 questionnaire about Nanofarm

A questionnaire has been made about the Nanofarm project and given to a group of people to fill it out. It aims to know the extent to which people want this project and to take some advice from them in order to benefit from the implementation of the project according to the people's desire

The questionnaire is attached in Appendix B.

2.3 conclusion

It was chosen hydroponics inside the Nanofarm after identifying them and their system, so it was the most appropriate because the crop is grown without soil contaminated with diseases and agricultural pests, unlike what happens with traditional and organic agriculture, also dispensed with the traditional methods used for agricultural such as tillage, fertilization and traditional irrigation, so the economic benefit of Hydroponics is much better, because the period of plant growth has become less within the Nanofarm.

Chapter 3

Proposed design of Nanofarm

3.1 Conceptual design of Nanofarm

3.1.1 Design the agricultural basin

3.1.2 Design the box of Nanofarm

3.2 Component of Nanofarm

3.3 Mechanism working of Nanofarm

Chapter 3

This chapter contain the parts used for building of the Nanofarm with clarification of the function of each part and the principle of the work of each part within the system, and show the principle of the work of all parts in system by algorithm, and the design of the system.

3.1Conceptual design of Nanofarm

Nanofarm is designed in two stages:-

1. **Design the agricultural basin.**
2. **Design the box of Nanofarm.**

3.1.1Design the agricultural basin

Agricultural basin consists of plastic pipe and external structure of it.

1) Plastic pipe

The diameter of the pipe is equal 10 cm, the distance between the pipe and the other is equal 8 cm, the diameter of the farming hole is equal 7 cm, and the distance between each hole is equal 8 cm see figure 3.1. Based on this dimensions, planting was chosen 9 small parsley on 3 pipe, in each pipe 3 of small parsley. Where the beginning of plastic pipes contains entrance of the water for the growth of parsley plant that coming by the water pump inside basin, and the end of the plastic pipes contains water drain to return water into the basin see figure 3.2 , so the parsley irrigation cycle will work Integrated.

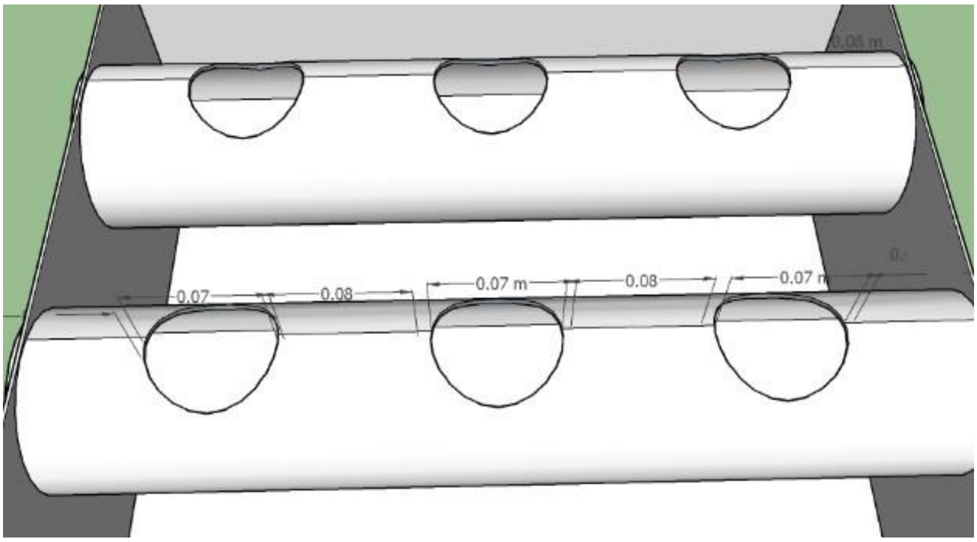

Figure 3.1: The plastic pipe**.**

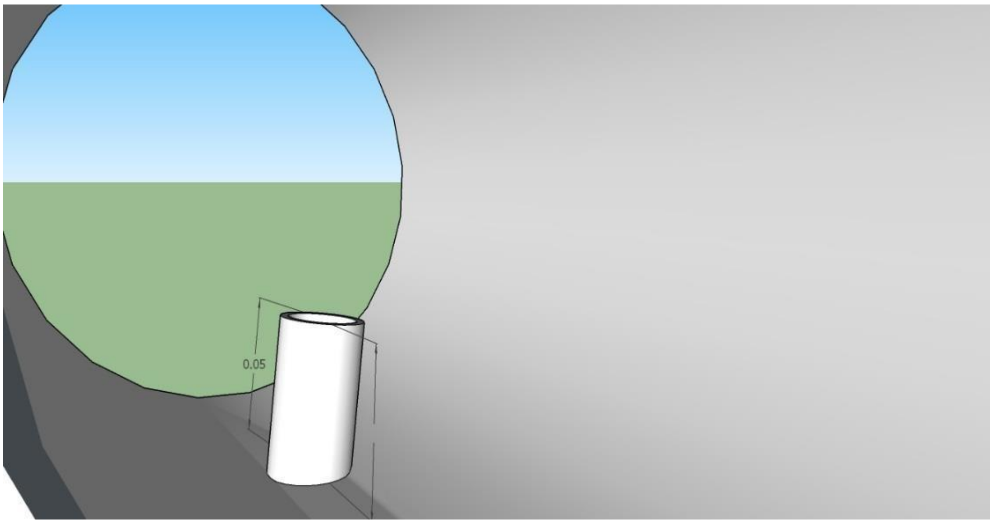

Figure 3.2: The water drain**.**

2) External structure of agricultural basin

The agricultural basin dimensions are (20, 62, 53) cm (Height, Width, Depth), made of stainless steel material because the water is inside it see figure 3.3 and figure 3.4.

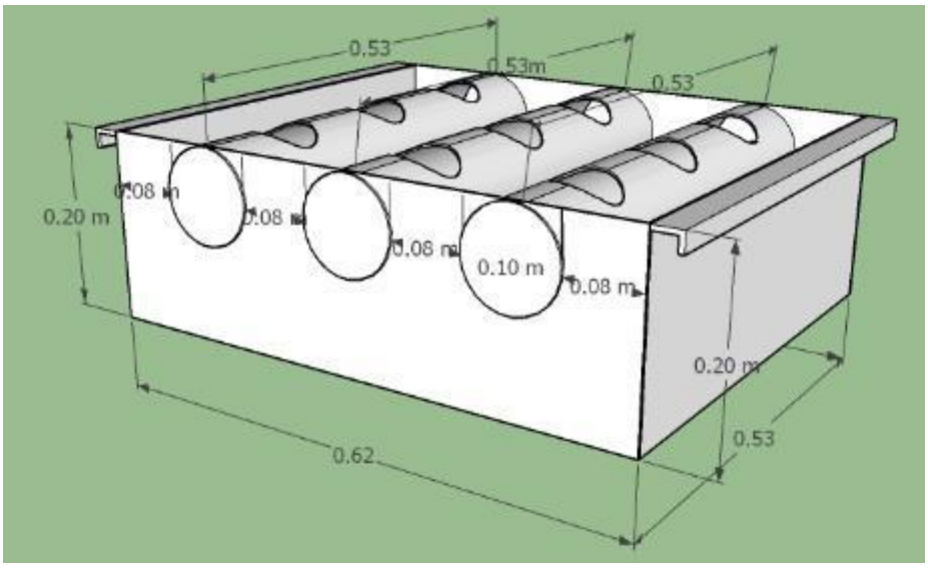

Figure 3.3: The front shape of agricultural basin**.**

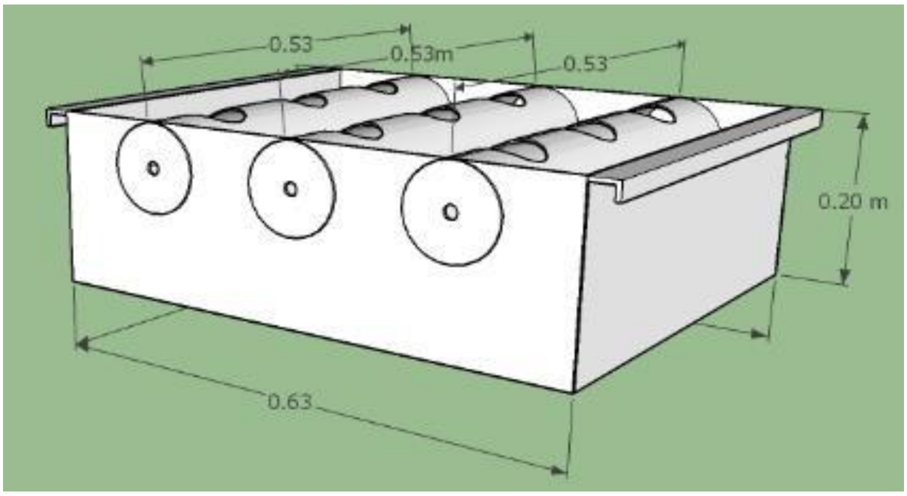

Figure 3.4: The rear shape of agricultural basin**.**

3.1.2Design the box of Nanofarm

It's highly needed to justify and detail the design that describing the project and the reasons for choosing this design. Therefore, it was necessary to visit the agricultural places to ask about some things related to the agricultural of parsley, the appropriate temperature and humidity were determined for the growth of it and the pH needed for hydroponics used, the length of the parsley plant ranges between (20_40) centimeters when ready to harvest, that has been known from visiting agricultural places, and the space which placed heating lamp and UV lamp in it, Which is about 20 centimeters. Based on this, and dimensions of the design of the agriculture basin, was select the appropriate dimensions to design the box of Nanofarm see figure 3.5.

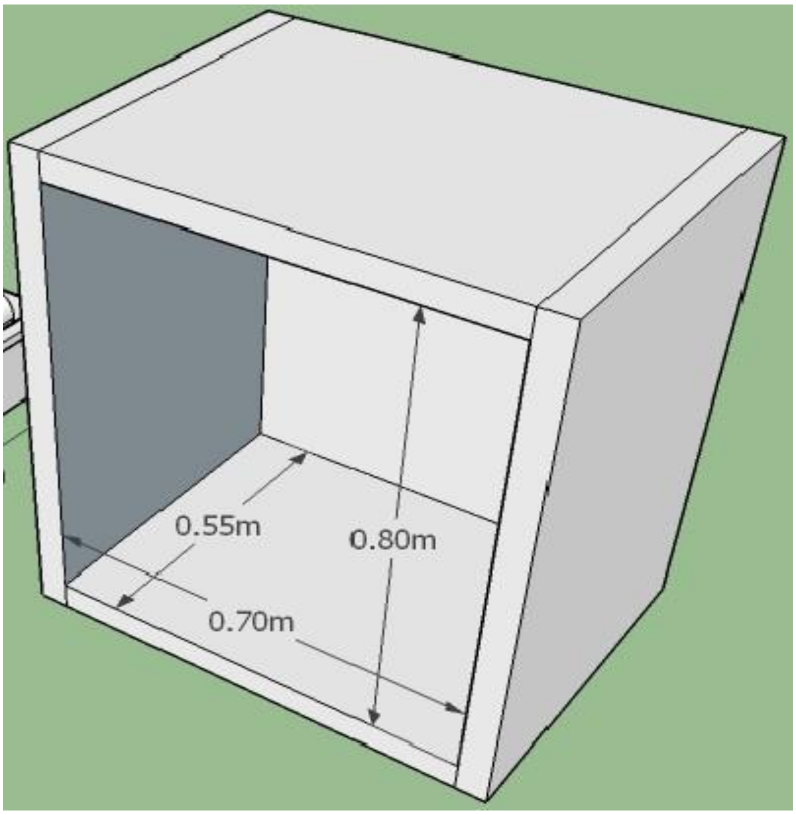

Figure 3.5: The box of Nanofarm**.**

3.2Component of Nanofarm

1) Arduino

The Arduino Mega 2560 is microcontroller board based on the datasheet. It has 54 digital input/output pins (of which 14 can be used as outputs), 16 analog inputs, 4 (hardware serial ports), a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button see figure 3.10 . It contains everything needed to support the microcontroller; connected it to a computer with a USB cable or power it with a AC-or-DC adapter or battery to get started. linking and program the temperature sensor, humidity sensor and pH sensor by the Arduino through the conditions and commands that writing in the programming code see figure 3.6.

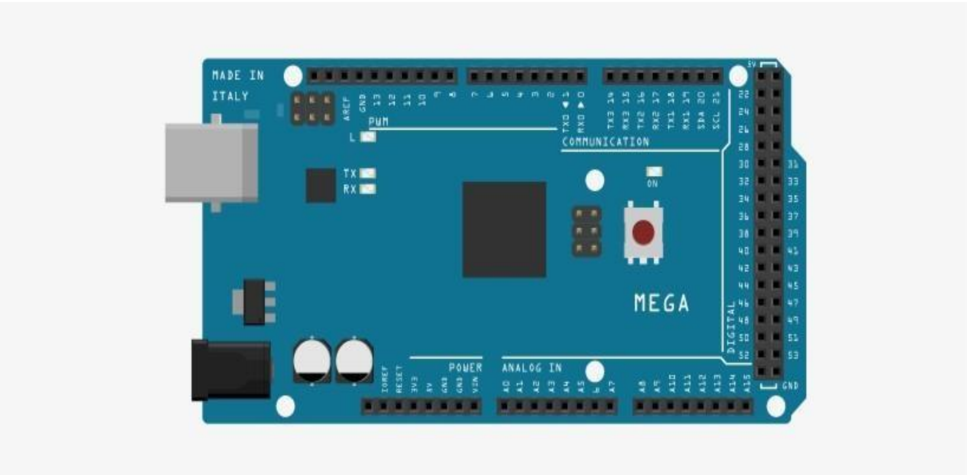

Figure 3.6: The Arduino**.**

2) Humidity and temperature sensor (DHT11)

DHT11 sensor measures and provides humidity and temperature values serially over a single wire. It can measure relative humidity in percentage (20 to 90% RH) and temperature in degree Celsius in the range of 0 to 50°C. This sensor was used to measure the temperature and humidity inside the Nanofrm see figure 3.7, figure 3.8 and figure 3.9.

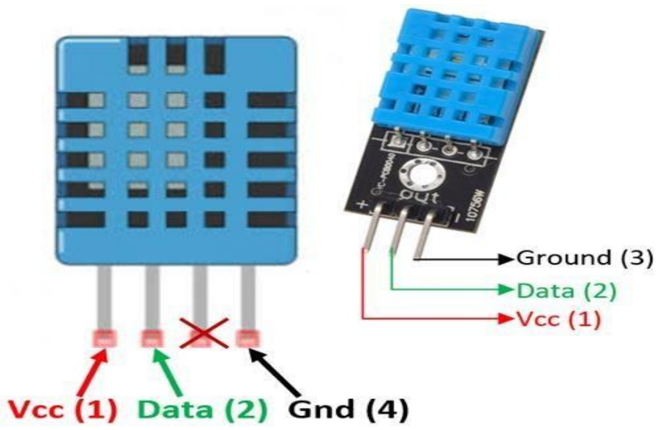

Figure 3.7: DHT11 sensor.

1	Vcc	Power supply 3.5V to 5.5V
2	Data	Outputs both Temperature and Humidity through serial Data
3	NC	No Connection and hence not used
4	Ground	Connected to the ground of the circuit

Figure 3.8: Pin identification and configuration of DHT11 senor.

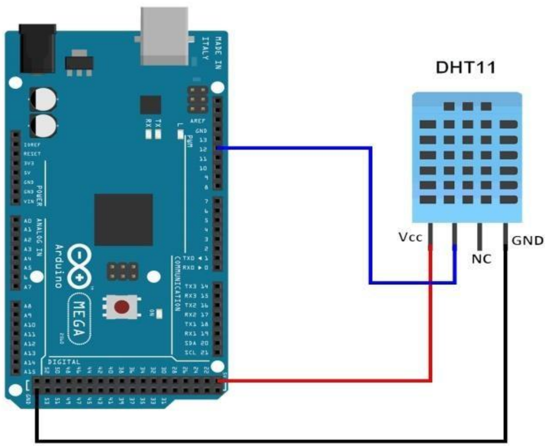

Figure 3.9: DHT11 sensor connection with Arduino.

3) Ph. sensor

This type of sensor is able to measure the amount of alkalinity and acidity in water and other solutions. When used correctly, pH sensors are able to ensure the safety and quality of a product and the processes that occur within a wastewater or manufacturing plant. In most cases, the standard pH scale is represented by a value that can range from 0-14. When a substance has a pH value of seven, this is considered to be neutral. Substances with a pH value above seven represent higher amounts of alkalinity whereas substances with a pH value that's lower than seven are believed to be more acidic. Power supply unit: + 5.00V, measurement range: 0-14ph, accuracy: ± 0.1ph (25 ℃), response time: ≤ 1 min. This sensor was used to measure the acidity of irrigation water see figure 3.10.

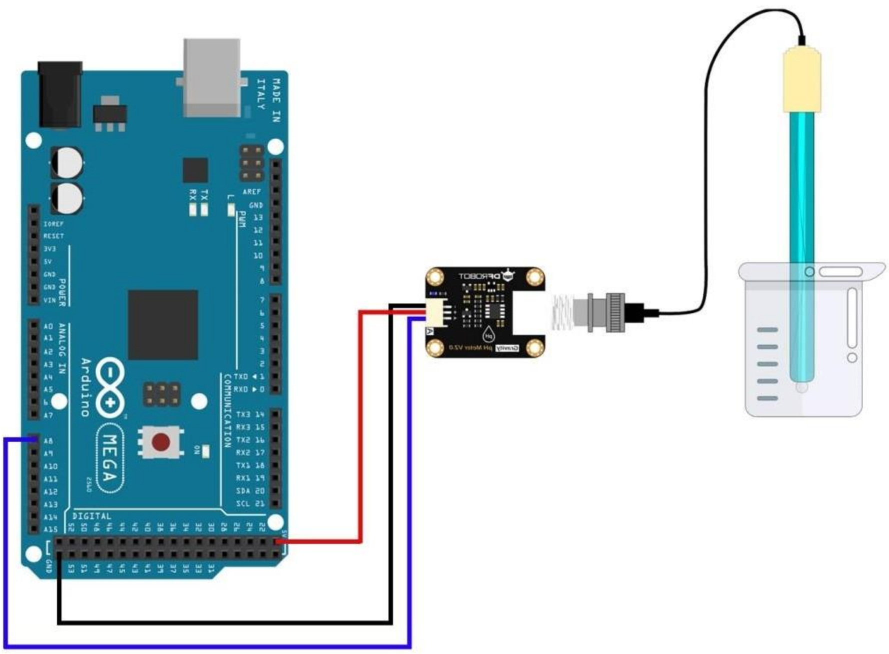

Figure 3.10: PH sensor connection with Arduino.

4) Heat lamp

Heat lamps 220 volt , 60 watt are mainly designed to be used in a grow room or greenhouse. is used light of heat lamp inside Nanofarm to keep the temperature closer to the grow conditions that most plants love see figure 3.11.

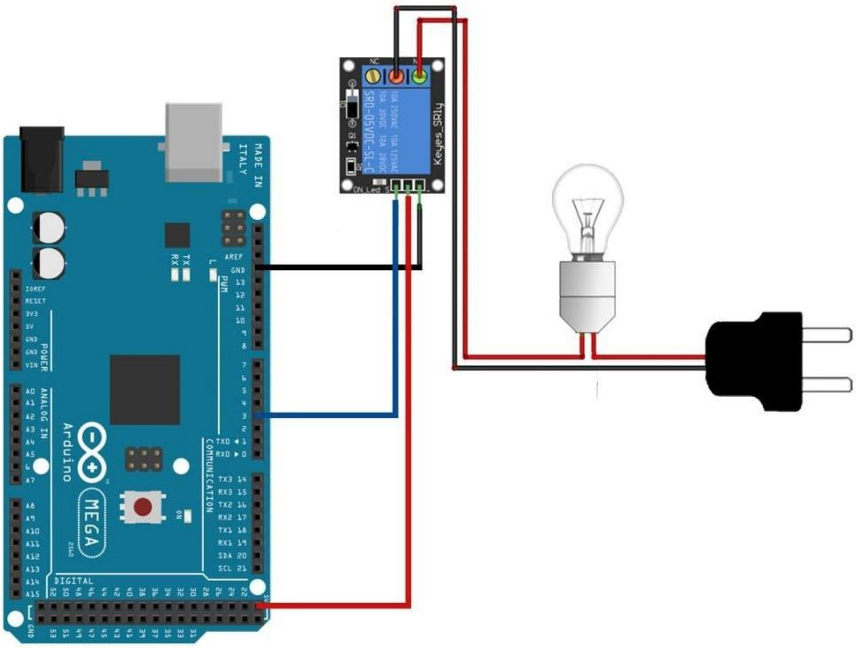

Figure 3.11: Heat lamp connection with Arduino.

5) Ultraviolet (UV) lamp

Ultraviolet light can speed up the germination process for starting seeds when grown indoors. As growers transplant seedlings to more intense light sources, UV strengthens the plants, better preparing them for high intensity light. Transplanting seedlings from low intensity lighting to high intensity lighting can shock or slow the plant’s growth. This is especially true when moving young plants from indoor to outdoor. Exposure to UV in the early stages of plant growth reduces shock time and speeds up the production process see figure 3.12.

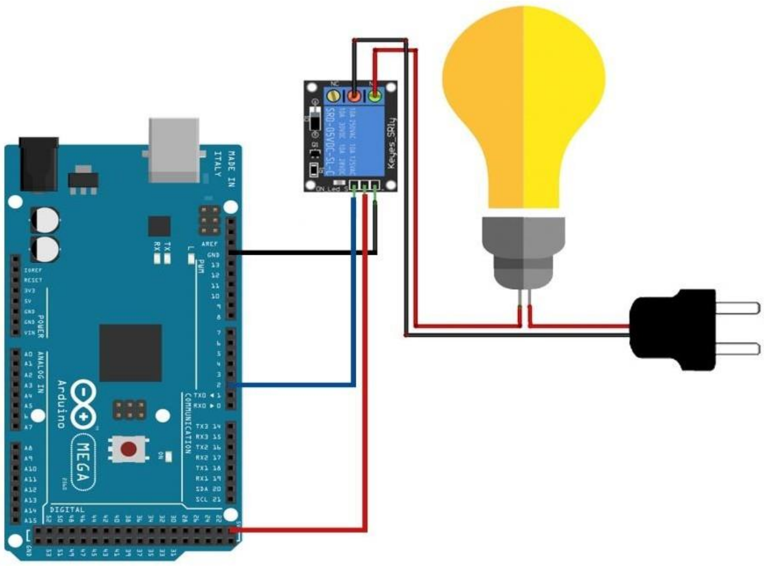

Figure 3.12: UV lamp connection with Arduino**.**

6) Air pump

The function of this pump is pump air into the water tank to maintain the proper oxygen content see figure 3.13.

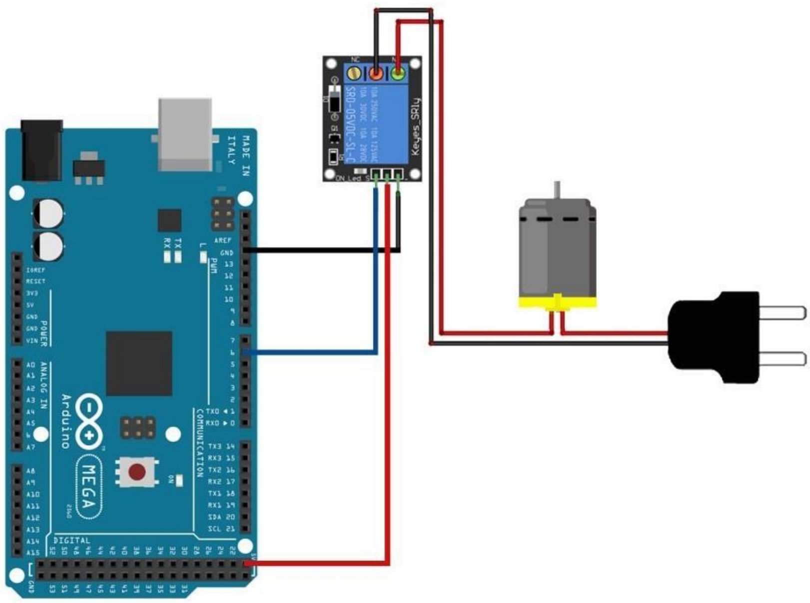

Figure 3.13: Air pump connection with Arduino**.**

7) Water pump

It must be installed below the water level, and DC pump is safety, stable, long lifespan, energy saving. We use it instead of AC pumps, because the continuous running is no problem, the pump will have a super long lifespan if correct using. The water pump will be permanently irrigated within the system due to use of hydroponics, the water pump gives flow rate 1 liters/min see figure 3.14.

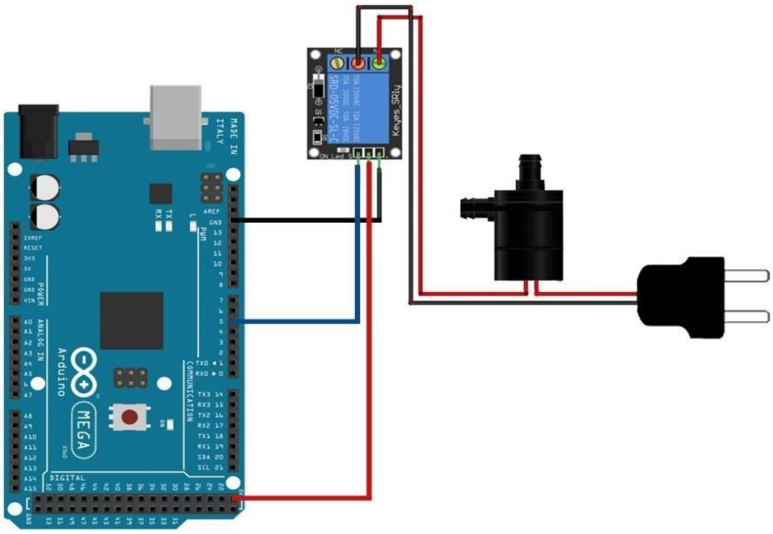

Figure 3.14: Water pump connection with Arduino.

8) Fan

The function of the fan in this system is to work when the humidity level is high in order to distribute the air inside the system and return the humidity to the required level see figure 3.15.

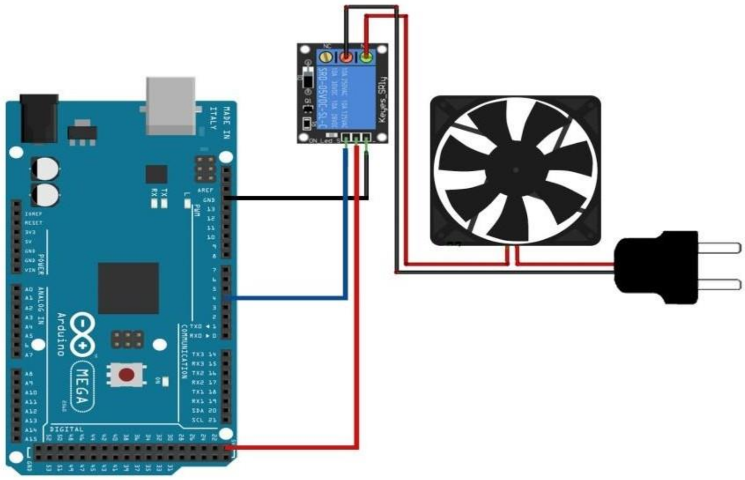

Figure 3.15: Fan connection with Arduino.

9) Small LCD

The LCD display the value of temperature and humidity inside the system, PH value of the water, time and date from RTC see figure 3.16.

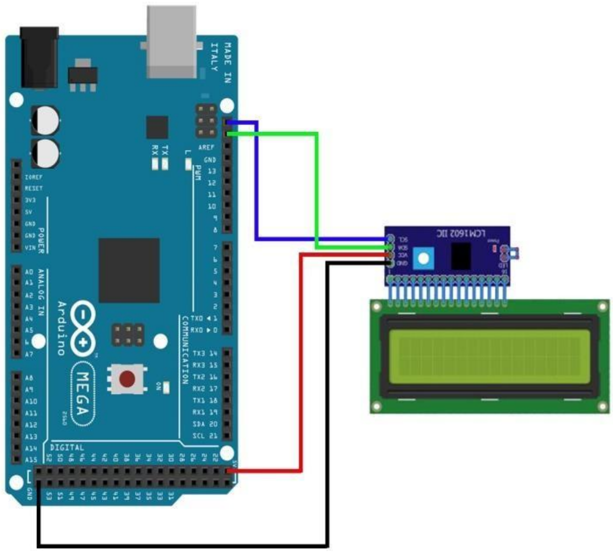

Figure 3.16: Small LCD connection with Arduino.

10) Real time clock (RTC)

Is a computer clock (most often in the form of an integrated circuit) that keeps track of the current time, although the term often refers to the devices in personal computers, servers and embedded systems, RTCs are present in almost any electronic device which needs to keep accurate time. Using RTC in the project because the UV lamp inside the Nanofarm working from 8 am to 8 pm see figure 3.17.

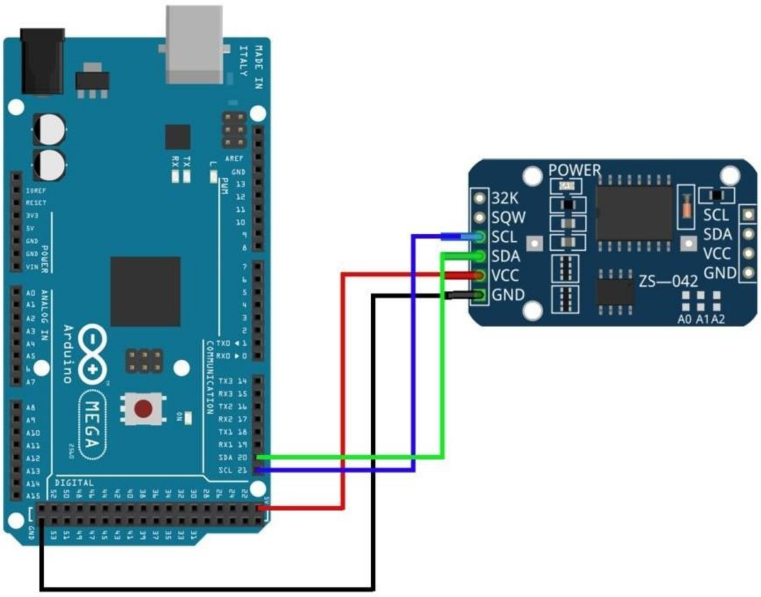

Figure 3.17: RTC connection with Arduino.

11) Electric solenoid valve

A solenoid valve is an electromechanically operated valve, solenoid valves are the most frequently used control elements in fluidics. Their tasks are to shut off, release, dose, distribute or mix fluids. In this project, the valve controls the flow of the acid and base into the irrigation water to maintain the required pH level in the water see figure 3.18.

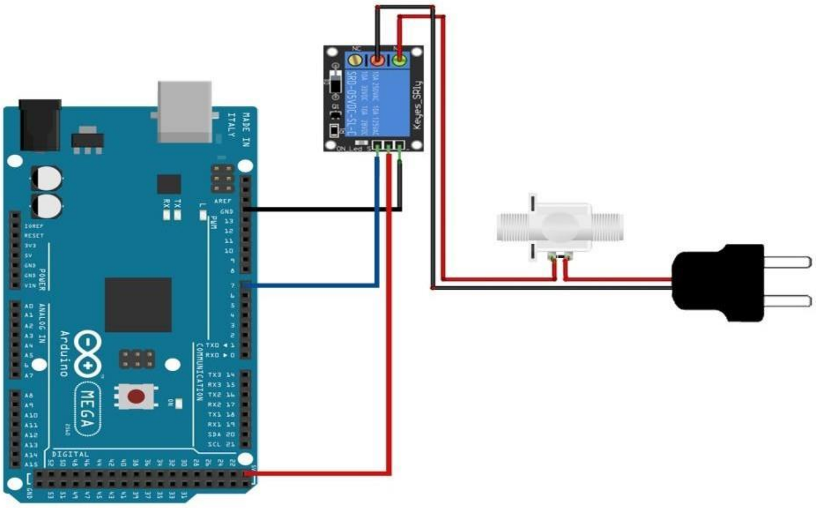

Figure 3.18: Electric solenoid valve connection with Arduino**.**

After mentioning the parts used for the project, the following figures show the location of each part inside the Nanofarm, see figure 3.19, 3.20, 3.21, 3.22. And the final shape of the project with all the pieces see figure 3.23 , 3.24.

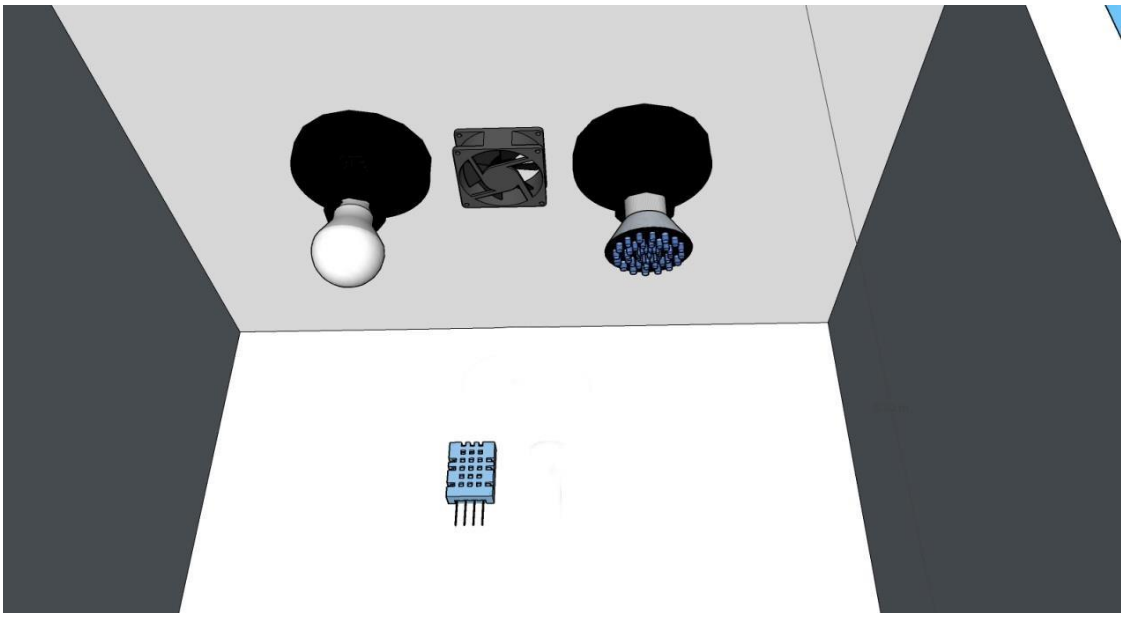

Figure 3.19: The sensor, lamps, and fan inside the box of Nanofarm**.**

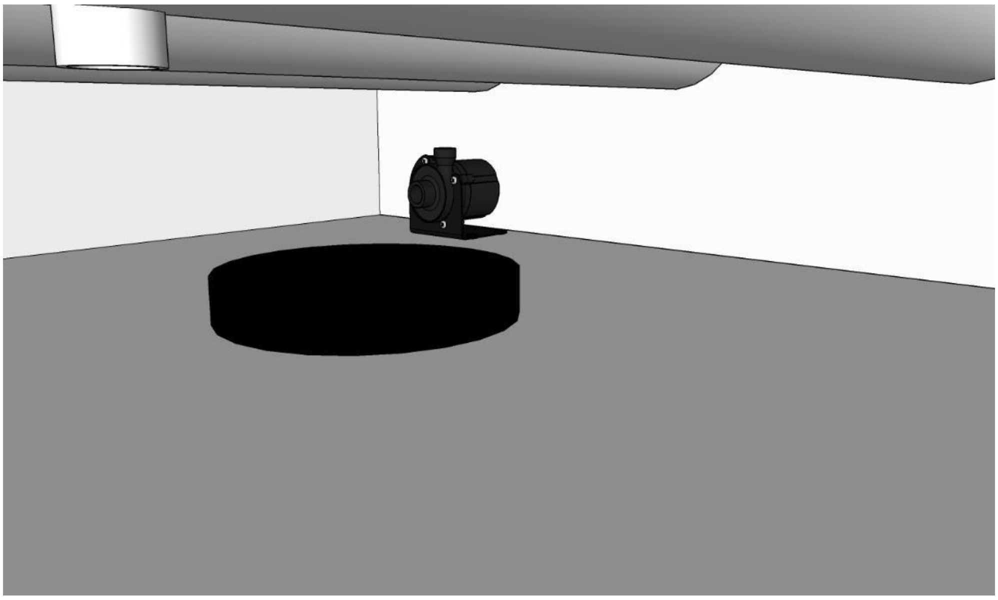

Figure 3.20: The water pump and air pump inside the agricultural basin**.**

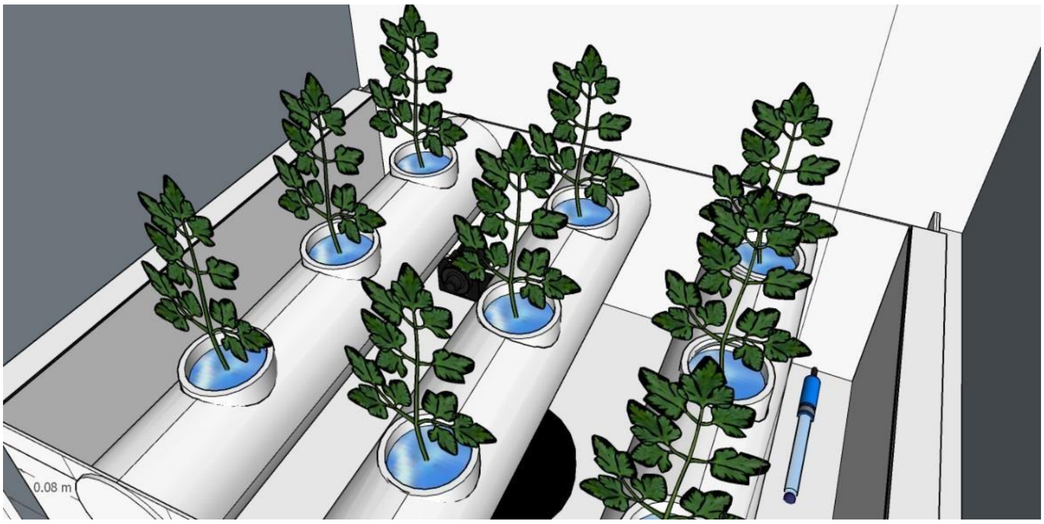

Figure 3.21: The PH sensor inside the agricultural basin**.**

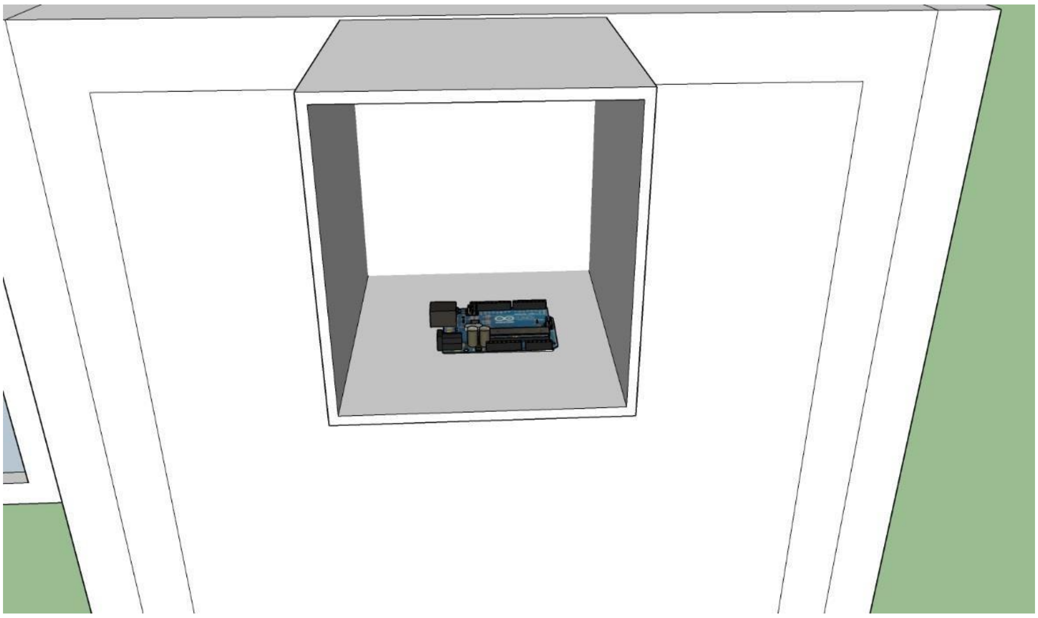

Figure 3.22: The Arduino inside the electrical box**.**

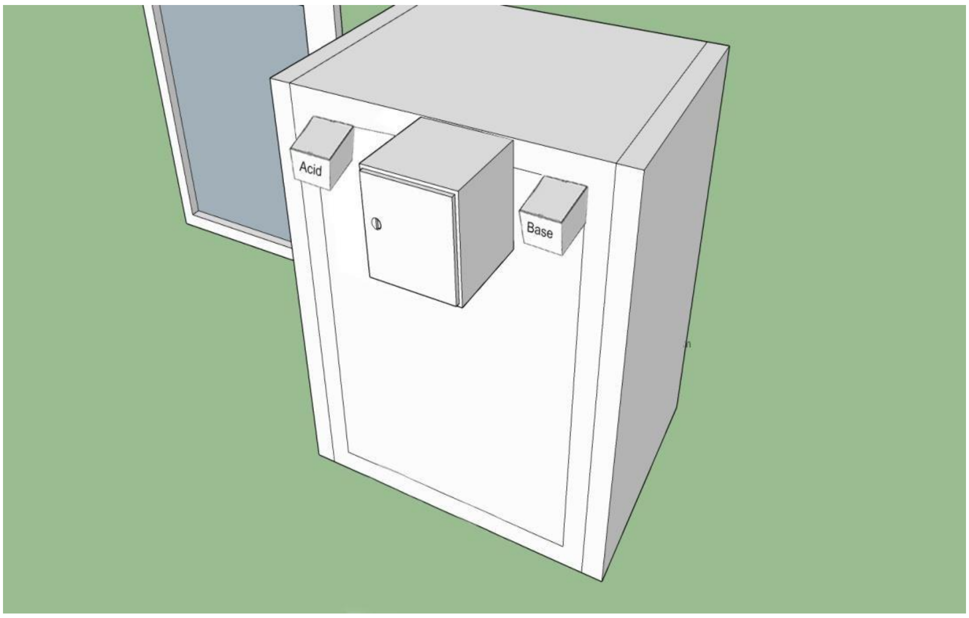

Figure 3.23: The rear shape of box Nanafarm**.**

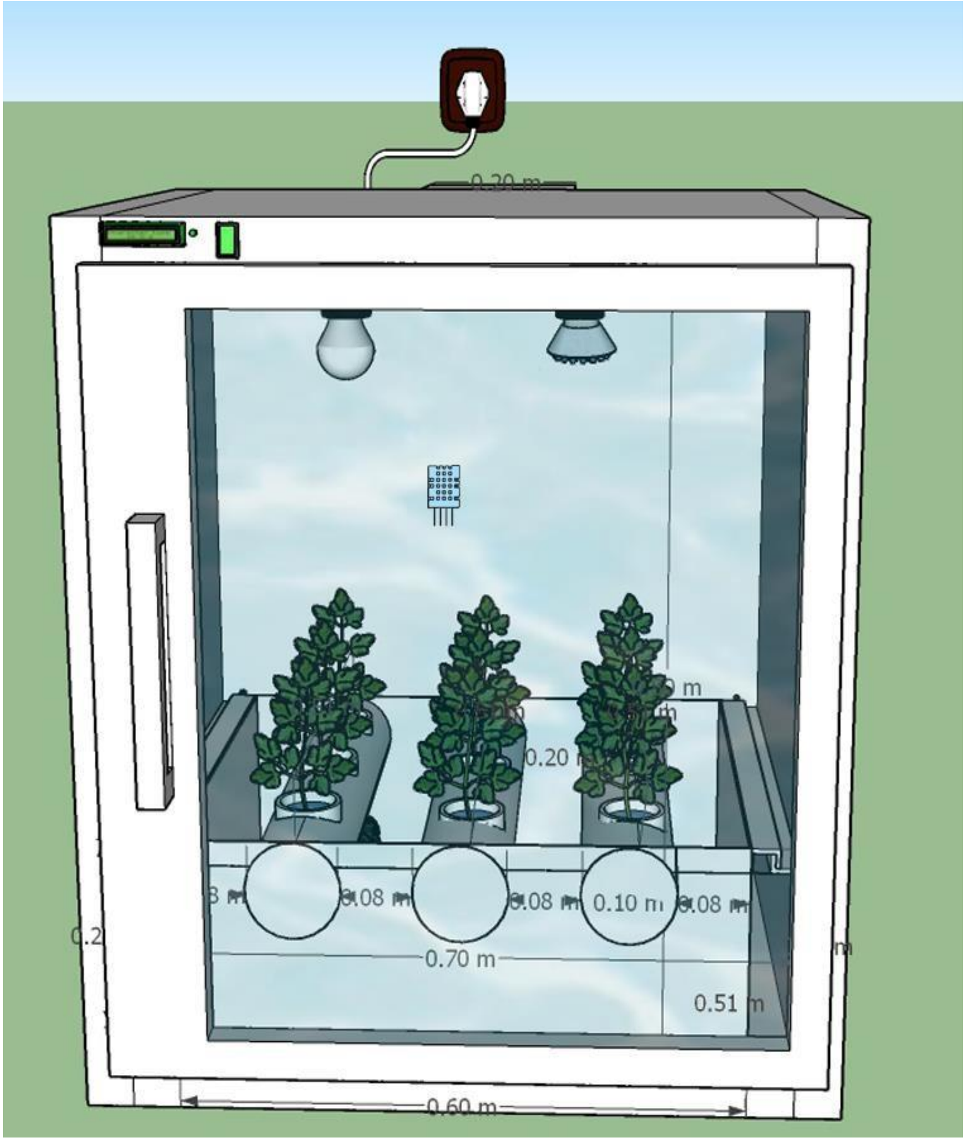

Figure 3.24: The final design of Nanofarm**.**

.

3.3Mechanism working of Nanofarm

The Nanofarm programming by C program during the Arduino , the flow of the program is from the initialization the sensors to the operating of the actuators. In the beginning, the Nanofarm checks from the analogue readings of the DHT11 sensor, PH sensor and time through the RTC, then displaying the sensing values on the LCD screen. After that, the program makes a decision based on the sensors readings, to control the heat lamp, UV lamp. The Nanofarm water pump will be working all times, when the humidity level is below 60% the fan will be turn off. If the humidity level is above 60%, the fan will be turn on. For the planting, the UV lamp will be switched on from 8 am to 8 pm and the heat lamp will be switched off, the fan will be turn on when the temperature is more than 25℃, but the heat lamp will be switched on again when the temperature is lower than 25℃. The UV lamp will be switched off after 8 pm because the plant will breathe at night, and the air pump inside the water is always running to provide Oxygen. For the water, the PH is monitored by the sensor because the addition of liquid fertilizer to water using in hydroponics, where the value should be between (5.8_6.5), if the PH below 5.8 the base will be added during turn on the base electric solenoid valve, and if the PH more than 6.5 the acid will be added during turn on the acid electric solenoid valve, the salinity of the water will be controlled by the PH sensor. With the following figure 3.25 of algorithm illustrating the overall working principle of the parts of Nanofarm.

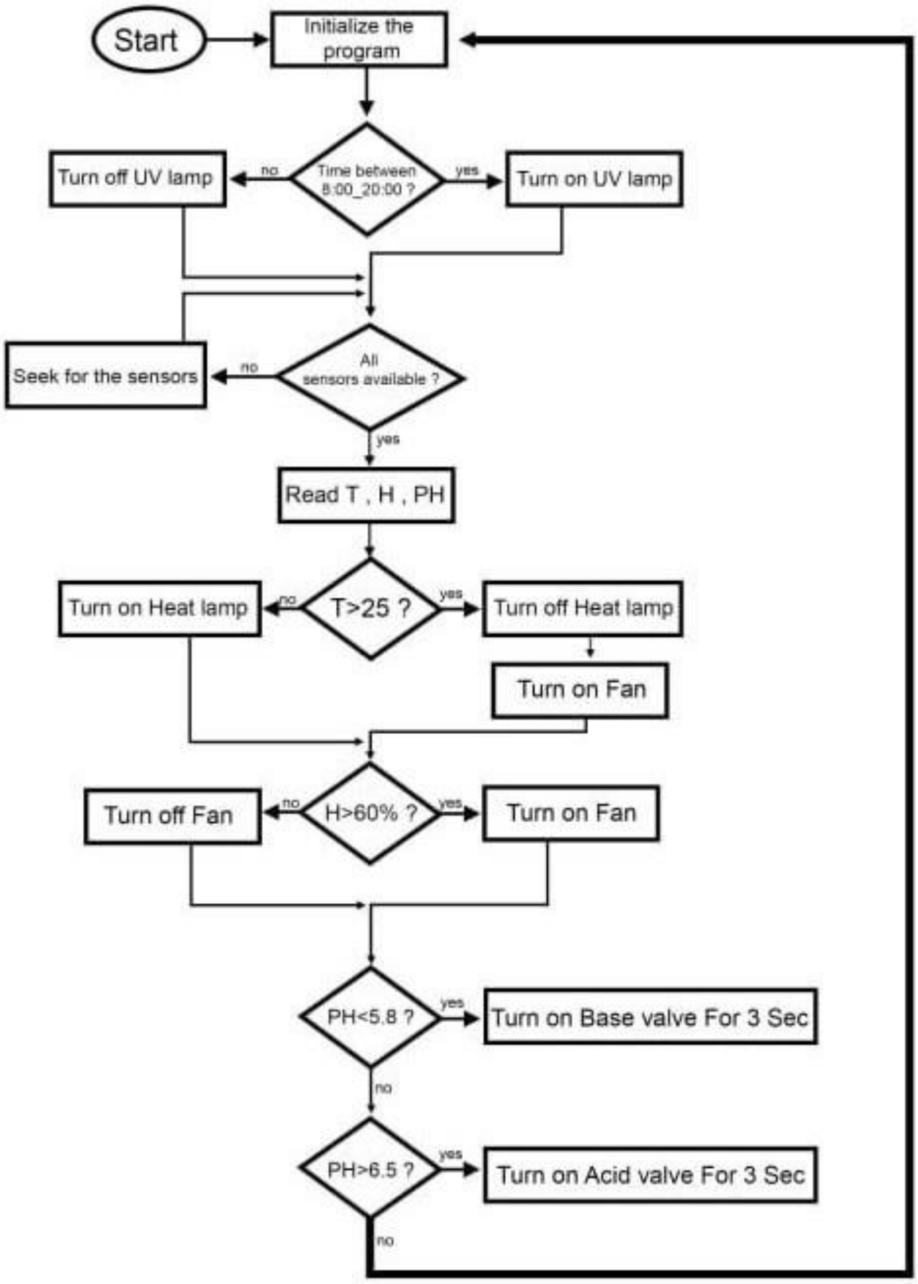

Figure 3.25: The flowchart of algorithm Nanofarm**.**

The Programming code shows how the microcontroller's work and what operation it does using the C language for its compiler as added in the appendix A

Chapter 4

Control Architecture and Calculation

4.1 Calculations the design of Nanofarm

4.2 Building electrical design of Nanofarm

4.3 Comparison between planting of parsley by using Nanofarm and by using soil

Chapter 4

This chapter will discuss the necessary calculations of the volumes of water used in the project in proportion to the flow of water leaving the pump, and control design of the Nanofarm in order to obtain the possible optimal desired outputs in high precision and accuracy. On the other hand, the building electrical design of Nanofarm will be clarified using figure 4.1 and an explanation of the control procedure.

4.1Calculations of the design of Nanofarm

1) The volume of water inside agricultural basin where put irrigation water in it:-

Volume of water inside agricultural basin = x *y *z

= 0.62*0.53*0.1

= 0.03286m^3 = 32.86 liter

2) The volume of water required inside the pipe:-

Volume of water required inside the pipes = (L * (d/2) $^{\wedge 2}$ *pi)/2

= (0.53 *0.05$^{\wedge 2}$ *3.14)/2

= 4.1605 /2

= 2.08025 liter

3) The volume of water required inside three pipes:-

Volume=2.08025*3=6.24075 liter

4) Supposing the diameter of the pipe from the water pump to the planting pipe is equal 1 cm:-

Area of the pipe from the water pump to the planting pipe = $(0.01^{\wedge 2} * pi/4) = 0.785 * 10^{\wedge -4} m^{\wedge 2.}$

5) In this project, the water pump flow rate should be 1 liters/min:-

Flow rate =area * velocity

$(1*10^{\wedge -3})/60 = (\text{diameter}^{\wedge 2} * pi /4) * \text{velocity}$

$(1*10\wedge -3)/60 = (0.785 * 10^{\wedge -4}) * \text{velocity}$

Velocity=0.2m/sec the speed is appropriate to the flow of water leaving the pump

6) In hydroponics, inside the agricultural basin 30 liters of water, we need 2 cm^3 from nutrient solution (A_B) for 1 liter of water.

4.2Building electrical design of Nanofarm

With the following figure 4.1 illustrating the overall connection the parts of Nanofarm and the working principle:-

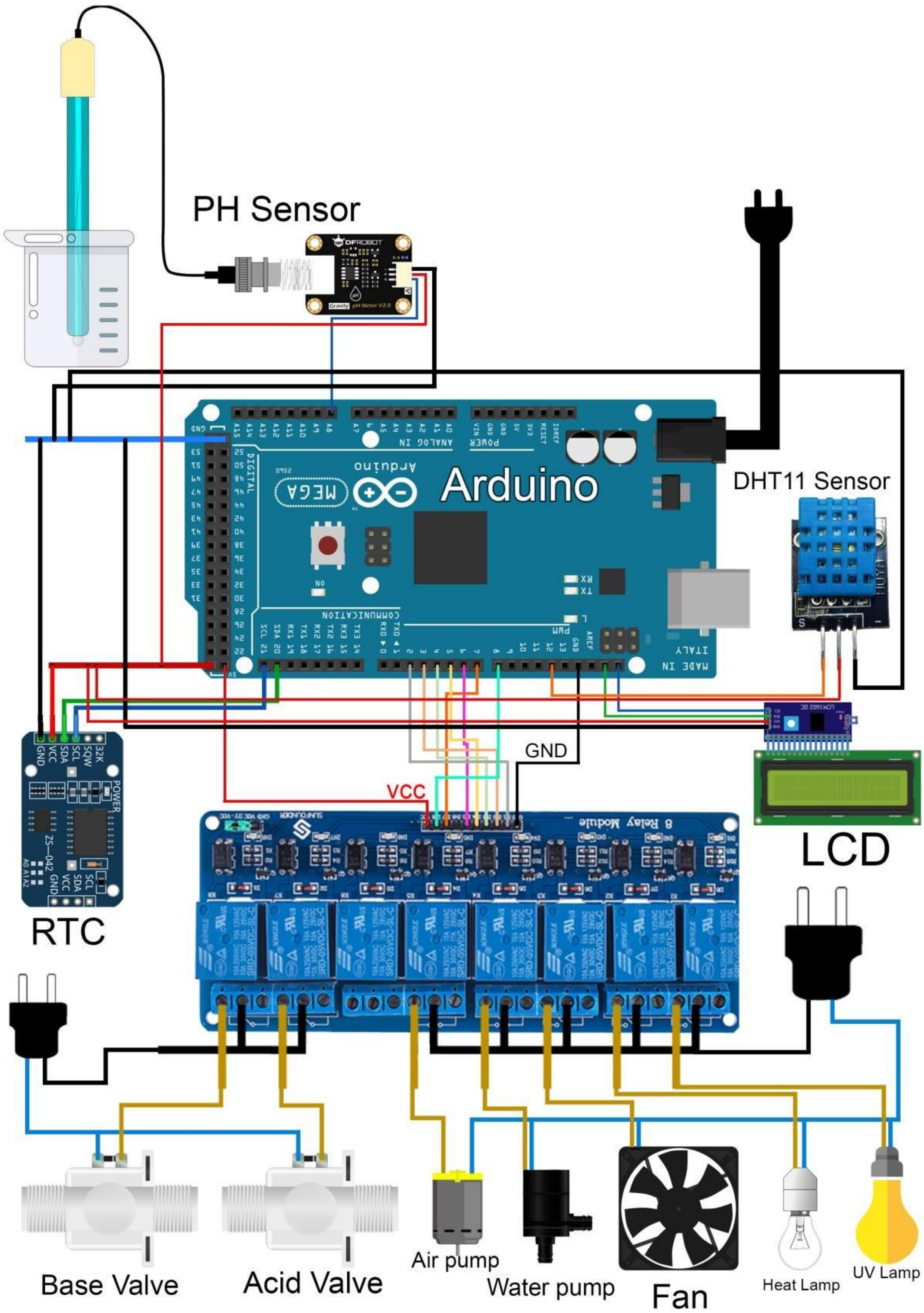

Figure 4.1: Electrical design of Nanofarm.

The parts of Nanofarm shown are connected to the Arduino Microcontroller,(PH sensor connected with Pin A8 as a signal line, common line of Vcc or 5 volt and common GND line), (DHT11 sensor connected with Pin 12 as a signal line, common line of Vcc or 5 volt and common GND line), (RTC connected with Pin 20 or Pin SCL as a clock line, and connected with Pin 21 or Pin SDA as a data line, common line of Vcc or 5 volt and common GND line), (LCD connected with Pin SCL as a clock line, and connected with Pin SDA as a data line, common line of Vcc or 5 volt and common GND line).As for the 220-volt parts, it was connected to the Arduino by 8 relay module, relay (1) connected with Pin 2 as a signal line to turn on UV lamp, relay (2) connected with Pin 3 as a signal line to turn on heat lamp, relay (3) connected with Pin 4 as a signal line to turn on fan, relay (4) connected with Pin 5 as a signal line to turn on water pump, relay (5) connected with Pin 6 as a signal line to turn on air pump, relay (7) connected with Pin 7 as a signal line to turn on acid electric solenoid valve, relay (8) connected with Pin 8 as a signal line to turn on base electric solenoid valve, and all the 220-volt parts connected with common line of Vcc or 5 volt and common GND line by 8 relay module.

4.3Comparison between planting of parsley by using Nanofarm and by using soil

Parsley was planted inside the Nanofarm and by using of soil under natural weather conditions and a comparison between the resulting crop in terms of growth period and weight, as parsley was growing inside the Nanofarm after 30 days faster than its growth in the soil see figure 4.2 , figure 4.3, and the weight of the parsley inside the Nanofarm was 60 grams more than the crop produced from the soil see figure 4.4 ,figure 4.5.

Figure 4.2: Parsley inside the Nanofarm after 30 days**.**

Figure 4.3: Parsley inside the soil after 30 days**.**

Figure 4.4: Weight of the parsley inside the Nanofarm**.**

Figure 4.5: Weight of the parsley inside the soil**.**

Conclusion

The project was successfully implemented and controlled well with an experimental procedure for planting of parsley inside Nanofarm which had a few barriers in the process of experimenting it, one of those obstacles was that calibrating liquid fertilizer for the water used in irrigation, but at the same time, success was achieved in reducing the growth period of the parsley plant inside the Nanofarm from 30 days to 40 days and obtaining a crop of better quality than the crop that was grown in soil. As the crop obtained from planting using Nanofarm reached a weight of 180 grams, and the crop obtained from planting using soil reached 124 grams.

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[1] Cuffari, Benedette. 2020. *What is Hydroponics?*. AZoCleantech, viewed 25 October 2020

[2] M H. Jensen, (1997), Hydroponics, Department of plant sciences university of Arizona, Tucson, P (1018).

[3] Espiritu Kevin ." hydroponic systems" .Epic Gardening .19 December 2013.

[4] Martin, M., & Molin, E. (2019). Environmental Assessment of an Urban Vertical Hydroponic Farming System in Sweden. Sustainability, 11(15), 4124.

[5] Morgan Lynette." Hydroponic Ebb and Flow, Flood & Drain Systems" .home hydro systems.

[6] Alex Weiss, Subasinghe Ruwan." The Food-Growing Appliance". Nanofarm created by replantable. 28 november 2017

[7] Eu, Kok Seng, et al. "Tomato Automation Cultivation System: Automatize Watering and Fertilizer Based On Sensory Information." MATEC Web of Conferences. Vol. 255. EDP Sciences, 2019.

Appendix A .Programing Code.

```
//DHT11 Sensor:

#include "DHT.h"

#define DHTPIN 12     // what digital pin we're connected to


#include <DS3231.h>

//////////////

unsigned long previousMillis = 0; // get current time

const long _time1 = 5000;         // waiting time (5 Sec)

const long _time2 = 6000;        // waiting time (60 Sec)

bool _step1 = true , _step2 = false , _step3 = false ;

bool mainStatus = true , secondStatus = false;

int sensVal ;

#define SensorPin A8          // the pH meter Analog output is connected with the
Arduinoâ€™s Analog

unsigned long int avgValue; //Store the average value of the sensor feedback

float b;

int buf[10],temp;

////////////////////

int RELAY_2=2;

int RELAY_3=3;

int RELAY_4=4;
```

```
int RELAY_5=5;

int RELAY_6=6;

////////////////////////////////

DS3231 rtc(SDA, SCL);

Time t;

const int OnHour = 8; //SET TIME TO ON RELAY (24 HOUR FORMAT)

const int OnMin = 10;

const int OffHour = 20; //SET TIME TO OFF RELAY

const int OffMin = 10;

///////////////////////////////

#define mainValve  7            // main valve Pin 13

#define secondValve  8          // second valve Pin 12

///////

#define DHTTYPE DHT11 // DHT 11

DHT dht(DHTPIN, DHTTYPE);

//I2C LCD:

#include <Wire.h> // Comes with Arduino IDE

#include <LiquidCrystal_I2C.h>


// Set the LCD I2C address

LiquidCrystal_I2C lcd(0x27,16,4); // set the LCD address to 0x3F for a 16 chars and 2
line display


void setup() {

   pinMode(RELAY_2, OUTPUT);
```

```
  pinMode( RELAY_3 , OUTPUT);
pinMode( RELAY_4 , OUTPUT);
pinMode( RELAY_5 , OUTPUT);
pinMode( RELAY_6 , OUTPUT);
   pinMode(mainValve, OUTPUT);
  pinMode(secondValve, OUTPUT);

  Serial.begin(9600);

  lcd.begin(16,4);
lcd.init(); // initialize the lcd
lcd.init();
// Print a message to the LCD.
lcd.backlight();
  dht.begin();
////////////////////////

rtc.begin();
  pinMode(RELAY_2, OUTPUT);
  digitalWrite(RELAY_2, LOW);
///////////////////////

}
void loop() {
```

```
//////////////////////////////

 t = rtc.getTime();
Serial.print(t.hour);
Serial.print(" hour(s), ");
Serial.print(t.min);
Serial.print(" minute(s)");
Serial.println(" ");
delay (1000);

if(t.hour == OnHour && t.min == OnMin){
  digitalWrite(RELAY_2,LOW);
  Serial.println("LIGHT ON");
  }

  else if(t.hour == OffHour && t.min == OffMin){
    digitalWrite(RELAY_2,HIGH);
    Serial.println("LIGHT OFF");
  }
///////////////////////////////////
 digitalWrite( RELAY_5 , LOW);
 digitalWrite( RELAY_6 , LOW);
```

```
int h = dht.readHumidity();
  int t = dht.readTemperature();
 // int temp = DHT.temperature;
 // int hum=DHT.humidity;

    // set the cursor to (0,0):
  lcd.setCursor(0, 0);
  // print from 0 to 9:

   lcd.print("Temp");
   lcd.print(t);
   lcd.print("C");
   lcd.print("||");
//
//lcd.print("Humidity: ");
lcd.print("Hum");
lcd.print(h);
lcd.print("%");
  if(t <20)
  {
    digitalWrite( RELAY_3,LOW);
  }
  else
  {
```

```
    digitalWrite(RELAY_3,HIGH);
  }
  delay(200);
  // set the cursor to (16,1):
// lcd.setCursor(0,1);

    if(h >60)
  {
    digitalWrite( RELAY_4,LOW);
  }
  else
  {
    digitalWrite(RELAY_4,HIGH);
  }
  delay(200);

  Serial.print("Temp: ");
  Serial.print(t);
  Serial.print("C, Humidity: ");
  Serial.print(h);
  Serial.println("%");
//////////////////////
   for(int i=0;i<10;i++)       //Get 10 sample value from the sensor for smooth the value
{
```

```
    buf[i]=analogRead(SensorPin);
    delay(10);
  }
  for(int i=0;i<9;i++)        //sort the analog from small to large
  {
    for(int j=i+1;j<10;j++)
    {
      if(buf[i]>buf[j])
      {
        temp=buf[i];
        buf[i]=buf[
        j]];
        buf[j]=temp;
      }
    }
  }
  avgValue=0;
for(int i=2;i<8;i++)                      //take the average value of 6 center sample
    avgValue+=buf[i];
  float phValue=(float)avgValue*5.0/1024/6; //convert the analog into millivolt
  phValue=3.5*phValue;                      //convert the millivolt into pH value
  Serial.print("    pH:");
  Serial.print(phValue,2);
Serial.println(" ");
lcd.setCursor (0,1);
```

```
lcd.print(phValue);
  /////////////////// Reset counter & open main valve
  if (_step1 == true) {
    if (mainStatus == true) {
      digitalWrite(mainValve , LOW);
      Serial.println("* MAIN VALVE IS OPEN");
}
    if (secondStatus == true) {
      digitalWrite(secondValve , LOW);
      Serial.println("* SECOND VALVE IS OPEN");
    }
    Serial.println("* WAITING 5 SEC ..");
    _step1 = false;
    _step2 = true;
    previousMillis = millis();     //Reset Counter
  }
////////////////// wait 5 sec & close main valve
  if (millis() - previousMillis >= _time1 & _step2 == true) {
    digitalWrite(mainValve , HIGH);
    digitalWrite(secondValve , HIGH);
    Serial.println("* CLOSING VALVES");
    Serial.println("* GET SENSOR VALUES EVERY 60 SEC ..");
    _step2 = false ;
    _step3 = true ;
```

```
    previousMillis = millis();     //Reset Counter
  }
////////////////// check sensor value every 60 Sec
  if (millis() - previousMillis >= _time2 & _step3 == true) {
   // sensVal = map(analogRead(A8), 0, 1024, 0, 128); //map A0 from 10-bit to 7-bit
values
    Serial.print("> SENSOR VALUE :");
    Serial.println(phValue);
    if  (phValue  >  6.5)  {
      mainStatus  =  false;
      secondStatus = true;
      _step3 = false ;
      _step1 = true ;
    }
    if (phValue < 5.8) {
      mainStatus = true;
      secondStatus = false;
      _step3 = false ;
      _step1 = true ;
    }
    previousMillis = millis();     //Reset Counter
  }
  ///////////////////////////////////
}
```

Appendix B. A questionnaire about Nanofarm

The questionnaire aims to introduce people to the idea of the project and take their different opinions about the project idea. The following questionnaire illustrating the support obtained from Palestine Polytechnic University students opinions about the project idea.


Your opinion for Nanofarm project ?

The Nanofarm is a small farm that controls the surrounding conditions in the growth of the plant inside it, by controlling the temperature, humidity and pH of the water used in hydroponics and lighting inside it.

* Required

Email address *

Your email

The Nanofarm

The questionnaire about Nanofarm**.**

Are you encouraged to use Nanofarm in home farming?

- ◯ Yes
- ◯ No
- ◯ Maybe

Would you prefer to eat the resulting crop from traditional farming or from farming using Nanofarm?

- ☐ Consume the resulting crop from traditional farming
- ☐ Consume the resulting crop from farming using Nanofarm

Does the use of Nanofarm in the field of agriculture in Palestine have an impact on agricultural development?

- ◯ Yes
- ◯ No
- ◯ Maybe

Does the use of Nanofarm have a positive impact on the family's economic situation?

- ◯ Yes
- ◯ No
- ◯ Maybe

The questionnaire about Nanofarm.

In your opinion, who is the highest in the transmission of agricultural diseases to the crop?

- [ ] In the use of traditional agriculture more than the use of agriculture by Nanofarm
- [ ] in agricultural use by Nanofarm more than traditional agriculture

Do you think Nanofarm is able to compensate for crop production due to the lack of agricultural areas in the current situation inside Palestine?

- ◯ Yes
- ◯ No
- ◯ Maybe

Is the farming of the crop inside the Nanofarm a complete protection of the crop from diseases and from the surrounding environmental conditions such as wind, insects, frost and heat waves?

- ◯ Yes
- ◯ No
- ◯ Maybe

The questionnaire about Nanofarm.

Do you expect Nanofarm agriculture to grow widely in Palestinian agriculture?

- Yes
- No
- Maybe

Are you ready to buy Nanofarm at a cost of 300$ and use it in your home for farming?

- Yes
- No
- Maybe

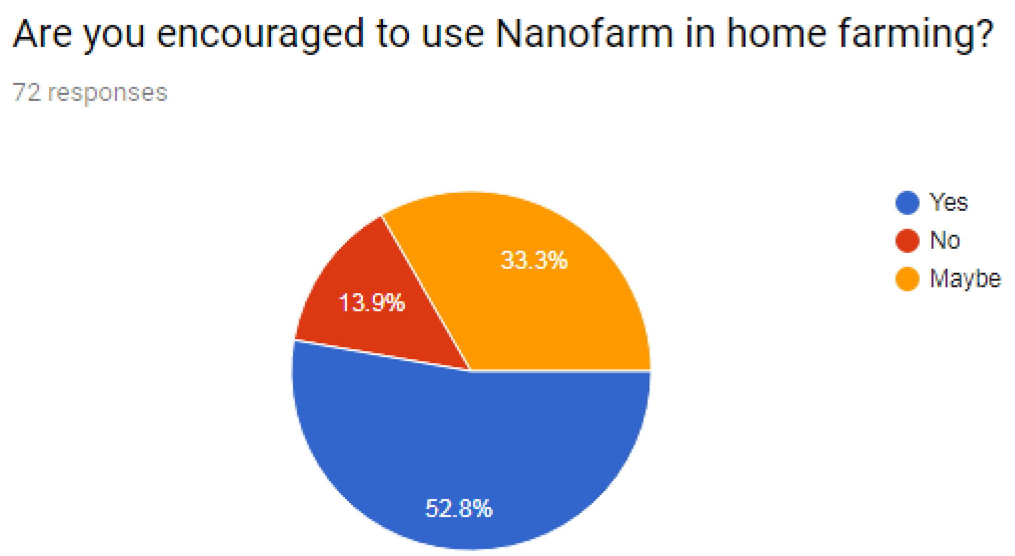
Write your opinion about (Nanofarm)

Your answer

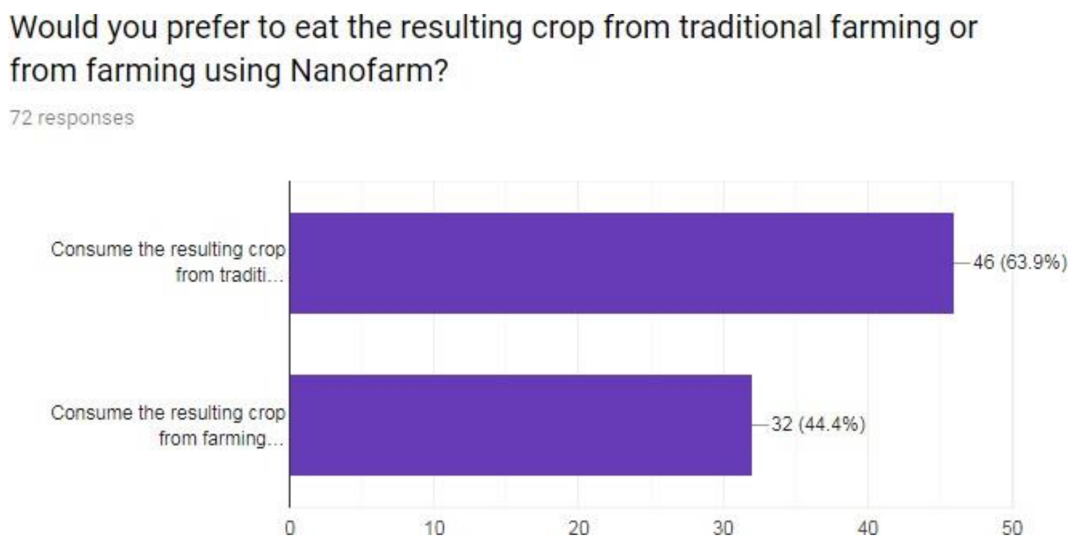
SUBMIT

Never submit passwords through Google Forms.

The questionnaire about Nanofarm.



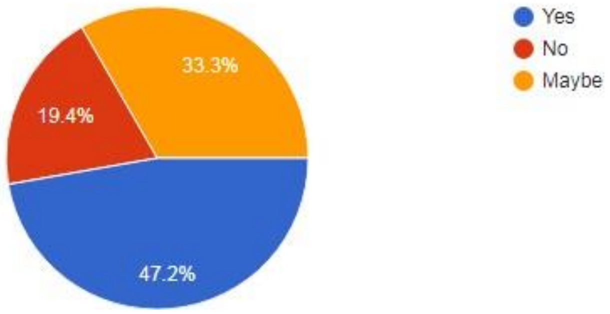
Analyze the results of the answers on the first question.



Analyze the results of the answers on the second question.

Does the use of Nanofarm in the field of agriculture in Palestine have an impact on agricultural development?

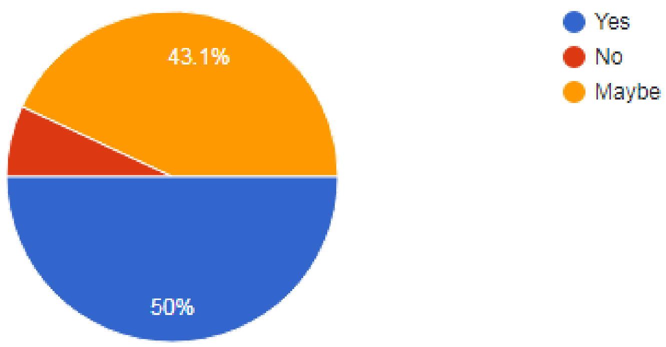
72 responses



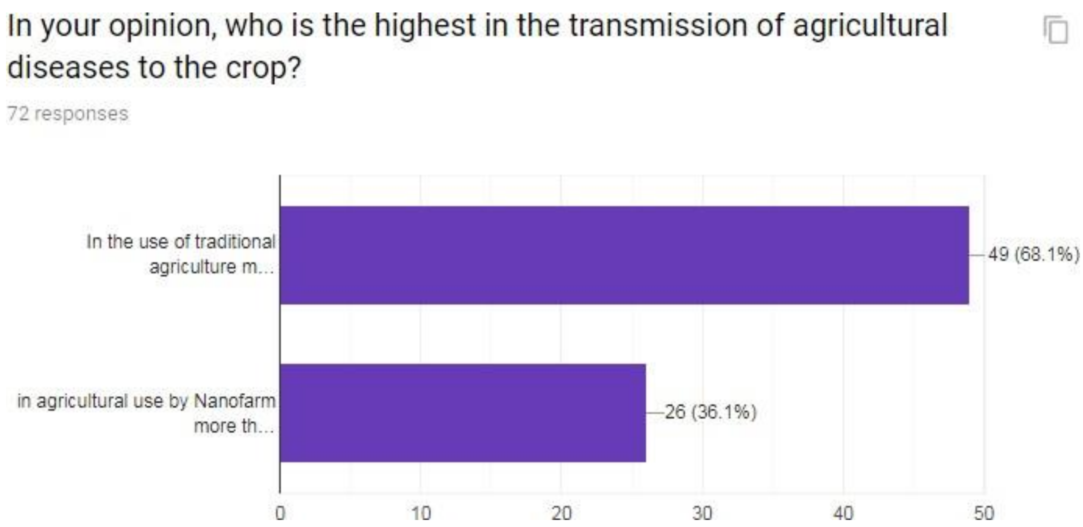
Analyze the results of the answers on the third question.

Does the use of Nanofarm have a positive impact on the family's economic situation?

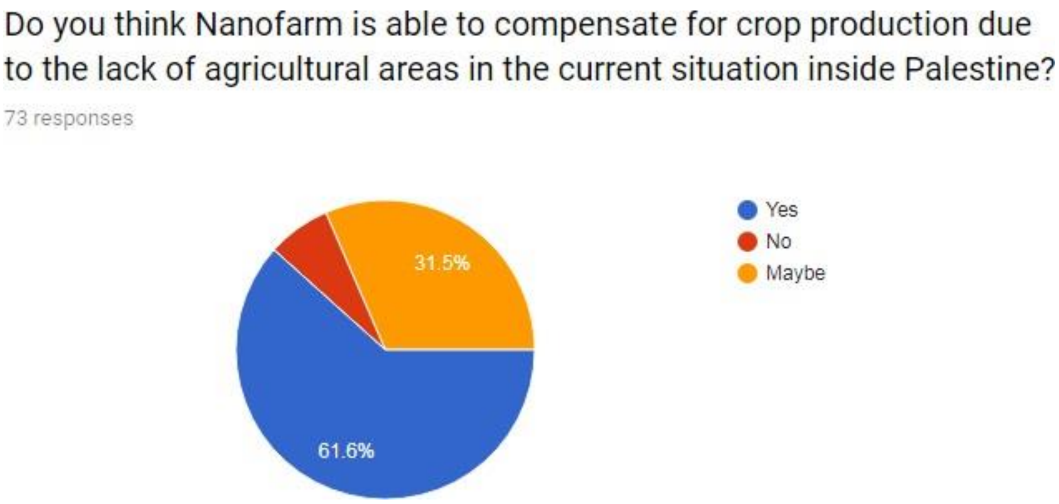
72 responses



Analyze the results of the answers on the fourth question.



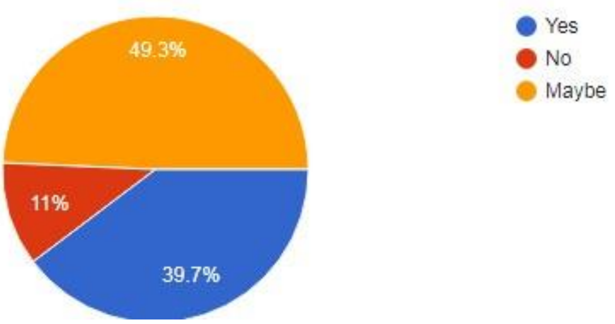
Analyze the results of the answers on the fifth question.



Analyze the results of the answers on the sixth question.

Is the farming of the crop inside the Nanofarm a complete protection of the crop from diseases and from the surrounding environmental conditions such as wind, insects, frost and heat waves?

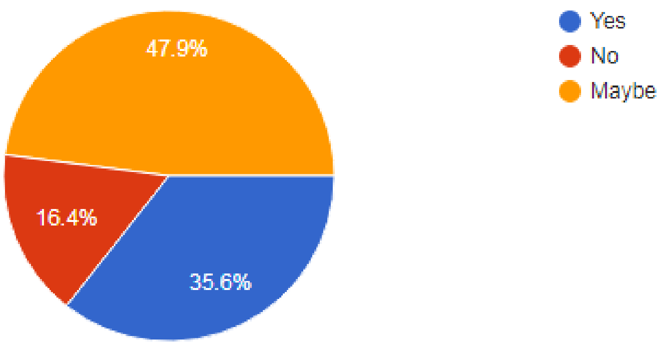
73 responses



Analyze the results of the answers on the seventh question.

Do you expect Nanofarm agriculture to grow widely in Palestinian agriculture?

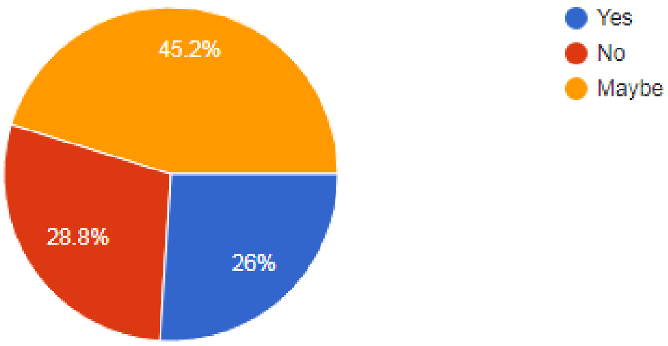
73 responses



Analyze the results of the answers on the eighth question.

Are you ready to buy Nanofarm at a cost of 300$ and use it in your home for farming?

73 responses



Analyze the results of the answers on the ninth question.

Write your opinion about (Nanofarm)

29 responses

Good luck

Good design for farming and it is a concept of the technology

I think the Nanofarm technology is very good and will improve economic of palestine..but it's very expensive

It's a good thing and maybe it's new in palestine ,i which from people to use this technical method and try to improve the palestinian agriculture field to be more and more rich country.

Nothing

I think nanofarm is the future of agriculture specially in Palestine

Yes

الفكرة بشوفها ممتازة بس يمكن تواجه مشاكل العقلية الرجعية شوي ببعض مناطق فلسطين

The opinions.

Write your opinion about (Nanofarm)

29 responses

I'm very interested in agriculture field, because of this I've created a small farm in my home. I like this project, your way of writing about it encouraged me to try Nanofarm as a new idea to improve my small farm.
Best wishes □.

The nanofarm its a good idea

The Nanofarm is effective system with high efficiency and maintains the Agricultural crop

Maybe good solving

I would like to buy a such a farm like that, which is green with the environment, but I am not with the idea of that all our plant sources became from such farms, the nature will be not exist, I am talking for long years, however, I think this farm will be a good project in Palestine.

Nanofarm can have positive and negative effects, but experiments must be done on agricultural products to ensure that there is no harm to an individual's health

This good technique about farming, we can use it in Palestine

the nanofarm is facilitate the hydroponic agriculture and provides the protection of plants from microbial infection
Wish you all the best in your project

The opinions.

Write your opinion about (Nanofarm)

29 responses

infection
Wish you all the best in your project

In my opnion, it would be more helpful for research approachs rather than the economic ones

Good idea □□

I dont now □

It's a very good project, i think it will be so helpful for farmers more than regular people

Maybe it's more healthy , the technology it used are good more than the traditional
I prefer the nanofarm because it using development technologies

Maybe

Must improve that

It's good for the farming of the palestain

A crop is relied on and closely tracked, which in my opinion is better than the crops that we buy without knowing the conditions you are exposed to.

I admire your ideas.

The opinions.

Also the following are the pictures of the Actual Built Project