Republic of Iraq

Ministry of Higher Education & Scientific Research
University of Kerbala
College of Engineering
Department of Civil Engineering

Evaluating of the performance of locally produced and used drip irrigation systems

A Thesis

Submitted to the Department of Civil Engineering, College of Engineering, the University of Kerbala in Partial Fulfillment of the Requirements for the Degree of Master of Science in Civil Engineering.

By

Jameel R Rawwash
BSc. in Civil Eng. / University of Babylon (2008)

Supervised by

Prof. Dr. Husam Hadi Alwan

بِسْمِ اللّهِ الرّحْمَٰنِ الرّحِيمِ

﴿ يَرْفَعِ اللّهُ الّذِينَ آمَنُوا مِنْكُمْ وَالّذِينَ أُوتُوا الْعِلْمَ
دَرَجَاتٍ وَاللّهُ بِمَا تَعْمَلُونَ خَبِيرٌ ﴾

صَدَقَ اللهُ العَلِّيُ العَظيم

سورة المجادلة / آيه (١١)

Abstract

Climate change and the construction of dams in riparian countries have led to a significant shortage of water resources in Iraq. Therefore, it was necessary to rationalize water consumption in agriculture by using systems is drip irrigation systems in which optimal water consumption is achieved. It is one of the most effective ways to rationalize water consumption in agriculture and needs to be performance evaluated. The present study was conducted on farms in the Iraqi province of Karbala. The drip irrigation system has been established in one of the governorate's farms, which consists of several types of irrigation networks from different sources that are used locally, in the governorate's farm. Most of these farms exist in the desert areas that are dedicated to the cultivation of tomatoes, cucumbers, and onions, and they are irrigated by wells water through using the drip irrigation system. Depending on the measurements of the discharge rates and pressure of the emitters, different parameters have been determined for drip irrigation systems. Three types of drip irrigation pipe systems were used in this study, two of them are locally produced and the third one is imported. Two emitters were used for each pipe type. When using the first type (emitter No one), the field emission uniformity ranged between 73.4% and 88%, the absolute emission uniformity ranged between73% and 86%, the design emission uniformity ranged between 70.8 and 85.2, the value of the statistical uniformity ranged from 74% to 89%, the value of the coefficient of variation ranges from 0.11 to 0.26, application efficiency ranges from 73.4% to 86.8%, variation of emitter flow rate ranges from 48.7% to 32.6% and pressure head variation ranges from 40% to 44.9%. When using the second type (emitter No two), the field emission uniformity ranged between 84% and 95%, the absolute emission uniformity ranged between 83% and 84%, the design emission uniformity

ranges between 79.7 and 93, the value of the statistical uniformity ranged from 86% to 95%, the value of the coefficient of variation ranges from 0.05 to 0.13, application efficiency ranges from 82.5% to 94%, variation of emitter flow rate ranges from 12.5% to 31% and pressure head variation ranges from 10.2% to 25,1% the pipes used in the experiments, are separate from the drippers and made of polyethylene plastic 16 mm diameter. These results show that the imported product is better than the local product, and the production values improve with increasing pressure and that the best evaluation was at pressure (1bar). The measured pressure change coincides with the calculated one with an absolute error ranging between 0.02 and 0.06 and this refers that emitter number two was better than emitter one. In addition, the coefficient of roughness was tested for several values, and it was found that the least error when comparing the program results of the calculated head from the equation and the values obtained from the field experiment was C=140 for local products. The IRRICAD software program has been used to re-design part of existent farm and evaluate its work, and when comparing the program results with the executed design, was found that the values of the diameters used in reality exceeded the values obtained by using this program.

SUPERVISOR CERTIFICATE

I certify that this thesis entitled "Evaluating of the performance of locally produced and used drip irrigation systems ", which is prepared by Engineer " Jameel R Rawwash", is under my supervision at the University of Kerbala, College of Engineering in partial fulfillment of the requirements for the degree of Master of Science in Civil Engineering.

Signature: Husam

Name: Prof. Dr. Husam H. Alwan

(Supervisor)

Date: 10 / 11 / 2021

LINGUISTIC CERTIFICATE

I certify that this thesis entitled "Evaluating of the performance of locally produced and used drip irrigation systems", which is prepared by Engineer "Jameel R Rawwash ", under my linguistic supervision. It was amended to meet the English style

Signature:.........

Linguistic Supervisor

Asst. lecturer. Noor Husam Jaber

Date....9 / ..11.. / 2021

EXAMINATION COMMITTEE CERTIFICATION

We certify that this thesis entitled "Evaluating of the performance of locally produced and used drip irrigation systems" and as an examining committee, we examined Engineer "Jameel R Rawwash " in its content and in what is connected with it, and that in our opinion it is adequate as a thesis for the degree of Master of Science in Civil Engineering.

Signature: Husam H.

Name: Prof.Dr. Husam Hadi Alwan

Date: .10.. / 11... / 2021

(Supervisor)

Signature: Omran Issa

Name: Assist.Prof. Dr. Omran Issa Mohammad

Date: .10. / .11... / 2021

(Member)

Signature: Riyadh Alsaadi

Name: Dr. Riyadh Jasim. Mohammed. Al-Saadi

Date: …... / …... / 2021

(Member)

Signature: A. S. Mustafa

Name: Prof.Dr. Ayad Sleibi Mustafa

Date: …... / …... / 2021

(Chairman)

Approval of the Department of Civil Engineering

Signature: ……………

Name: Dr. Raid R. A. Almuhanna

(Head of Civil Engineering Dept.)

Date: .16.. / 11... / 2021

Approval of the Deanery of College of Engineering

Signature: L.Sh.Rasheed

Name: Assist Prof. Dr. Laith Sh. Rasheed

(Dean of College of Engineering)

Date: .٢٣ .١١. / 2021

I dedicate this work

To my father and mother, who gave me affection and love; I say to them: you gave me life, hope, and the emergence of a passion for learning and knowledge.

To my dear wife; my loved daughters; my brothers, sisters, friends for their love and continuous prayers.

ACKNOWLEDGEMENTS

First of all, I thank Almighty Allah, who granted me the power to finish this work. I would like to thank my parents for their continuous support to complete my research work. I would like to thank the Director of my study and the academic supervisor, **Dr. Husam Hadi Alwan**, for his continuous assistance, suggestions, advice, and encouragement at all stages of my research. I would like to express my sincere gratitude and thanks to my dear wife for her patience and endure the hardships of research. Finally, many thanks go to the ones who gave me their help and I forgot to mention them.

Table of Contents

LIST OF FIGURES

LIST of TABLES

LIST OF SYMBOLS

h_{max}	maximum pressure heads	L
h_{min}	minimum pressure heads	L
A	the global area to be irrigated	L^2
q_X	Average of the highest 1/8th of the emitters flow rate	L/h
S_q	The standard deviation of the emitter flow	L
γ	Bulk density	M/L^3
v	The volume of the core sample	L^3
w_s	The dry weight of the sample	M
w_{wet}	The weight of the wet soil	M
w_{dry}	The weight of the dry soil	M
x	The exponent of emitter discharge	
SUc	Statistical uniformity coefficient	%
q_{min}	Minimum discharge of emitter	L/h
q_{ave}	average discharge of emitters	L/h
q_{max}	The average flow rate of the maximum 1/8 of the emitters	L/h
q_{var}	Variation of emitter flow rate	%
$q_{\frac{1}{4}}$	The lowest average value of (1/4) of the flow rate of an emitter	L/T
Gs	Specific gravity	
H	pressure head at the emitter	m
n	outlets number on a specific pipe	
A'	weigh the pycnometer with water and soil	M
$\boldsymbol{c_v}$	Coefficient of variation	
C	Constants	
d	depth of water	L
Ea	Efficiency of application	%
EU	Emission uniformity	%
EU_f	Emissions uniformity in field	%
EUa	Uniformity of absolute emissions	%
EU_d	Uniformity of design emission	%
h_{var}	pressure head variation	%

LIST OF ABBREVIATION

F_1	correction factor
CU	Coefficient of Uniformity
DIS	Drip Irrigation System
EU	Average Emissions uniformity
DS	Distributed Characteristics
DU	Distribution Uniformity value
OE	open environment
US	Statistical uniformity
UC	Uniformity Coefficient
NVPH	Naturally ventilated poly house
VPF	Variance due to performance of emitter in the field
RMSE	Root Mean Square Error
MBE	Mean bias error
MAPE	Mean absolute percentage error
TDS	Total Dissolved Solids
HDP	High Density Polyethylene
N	Number of emitters per plan
B	weight of the pycnometer with water only
P_A	Adjusted finer
H_f	head loss due to friction

Chapter One

Introduction

1.1 Background

Drip irrigation is one of the methods of irrigation and watering of trees and plants by providing the least sufficient amount of water for plants. Irrigation is of paramount importance in dry areas of the land, the lack of water resources is a major problem in regions of aridity and semi-aridity like Iraq.

In terms of water consumption and labor, a drip irrigation system is the most efficient but should be installed, designed, and maintained properly(Asif, 2015). Most vegetables' root systems are found in the top layer of the soil and required frequent irrigation, thus, a drip irrigation system is the most efficient and economical for irrigation for vegetable production (Sharu and Ab Razak, 2020)

Also, for increasing importance in wet areas, large amounts of water are lost due to leakage and evaporation, which represents the loss of a valuable resource at a high cost. The drip irrigation method has the potential to eliminate water stress for crops even under severe water scarcity conditions, through a network of emitters and pipes to deliver the water directly to the root zone (Narayanamoorthy *et al.*, 2018).

Water is a scarce source or available in inadequate amounts, so optimum usage is required by drip irrigation, which keeps water and raises yield. The proper timing and the volume of water to be applied are critical for effective irrigation. Excessive irrigation means the water and energy are wasted and could lead to filtering of nutrients from the root zone, erosion of topsoil, and a decrease in air content of the soil (Soomro *et al.*, 2013).

1.2 Problem Statement

The issue of water scarcity is one of the major challenges facing the world at present, and Iraq in particular because of the severe shortage of imports of the Tigris and Euphrates rivers, the lack of rain and snow, climate change, and global warming that led to the phenomenon of drought which includes the entire Middle East region, not only Iraq. This can result in a significant decrease in the amount of rain and snowfall, and a clear decrease in the water revenues of the Tigris and Euphrates rivers. There are several dams-built Euphrates and Tigris rivers in neighboring countries adjacent to Iraq which make shortages and poor quality of water in Iraq. Now, water resource management must be improved and water consumption should be reduced. The research's goal is to evaluate the hydraulic performance of drip irrigation systems produced and used, then make a comparison between them because of the increasing agricultural areas in Karbala Governorate which cultivated with a drip irrigation system.

1.3 Thesis Objectives

This research aims to conduct a field hydraulic evaluation of locally produced and used drip irrigation systems in the Iraqi province of holy Karbala. This will be achieved through the following objectives:

- Assessing the hydraulic performance of the drip irrigation systems by determining performance parameters for the drip irrigation system.
- Assessing the soil that is watered with this type of irrigation and determination of its engineering and physical properties.
- Determining the relationship between the head-discharge and coefficient of manufacturing variation for emitters.

- Comparing between different types of drip irrigation pipes produced and used locally
- Using different drippers in the evaluation process, according to what is used locally.
- Using a computer program to design a portion of drip irrigation for a certain farm and compare the program results with the field results.

1.4 Scope of the Research Work

Within the wide range of conditions, materials, and test methods, this research work has been accomplished within the following scope:

1- Three samples were selected for laboratory tests to determine their physical properties (Dry density, Specific gravity, and sieve analysis).

2 - All tests were performed at the University of Kerbala (UOK) laboratories and field site and according to standard specifications.

1.5 Thesis Structure

The thesis consists of six chapters to demonstrate the study work outcomes as listed below:

Chapter 1	Introduces the background of the research, problem statement, aim and objectives, scope of the research work, and finally the thesis layout.
Chapter 2	Reviews previous studies of the evaluation of drip irrigation system.
Chapter 3	Provides a summary of the theoretical aspects and all the mathematical equations used in the calculations.

Chapter 4	Describes soils types and their locations in the present study, adopted physical and laboratory tests to examine the selected soil, and finally research methodology.
Chapter 5	Illustrates the obtained results, analysis, interpretation and discussion.
Chapter 6	Presents the summary of the major findings of the study, conclusions, and recommendations.

Chapter two

Description of Drip Irrigation and Literature review

2.1Introduction

According to previous studies, drip (trickle) irrigation is the best irrigation system as compared to other irrigation methods because it offers high uniformity, Trickle irrigation systems typically use (30 to 50 percent) less water than the other irrigation systems as they supply just the water needed by plants (Alabas, 2013).The drip irrigation system is appropriate for most types of soil if well designed and used, the high percentage of silt raises the water demand for the irrigation system since the dripping water on soil depends on the soil type and the discharge of the emitter(Omran *et al.*, 2016). On clay soils, water should be slowly poured to avoid an accumulation of surface water and runoff, but on sandy soils, higher emitters discharge rates should be required to ensure all aspects of the soil are hydrated. (Abd *et al.*, 2006).

2.2 Components of a Drip Irrigation System

The drip irrigation system contains the source of water, control head, motors pump, main lines, sub-main lines, lateral lines, pressure gauges, valves, and emitters as shown in Figure (2.1) (Keller and Bliesner, 1990).

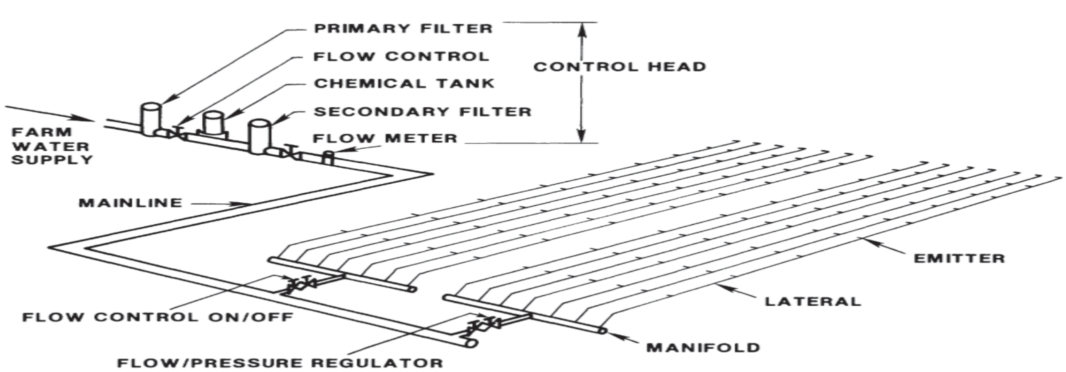

Figure 2. 1: Components of the drip irrigation system(Keller and Bliesner, 1990).

2.2.1 Pump unit

The pressure needed to forcing water into the system components, including the filter unit, fertilizer tank, mainline, laterals, and drippers are obtained by a pump of appropriate capacity. Centrifugal volute pumps are generally employed by motors or electric motors, to maintain desired pressure at the lateral sides, the water pressure desired to be Prepared should be suffice (Michael, 1978).

2.2.2 Mainlines

The mainline is the tubes that carry water from the supplying source to the sub mainline, usually, they are made of polyethylene hose or (PVC) and should be buried underground because they decompose when directly exposed to solar radiation (Brouwer *et al.*, 1988).

2.2.3 Sub mainline

The sub mainlines are the pipes that pass from valves to the lines of the lateral linked to a dripper. There is no sub-main pipe for many small drip systems, in those systems the drip tube connects directly to the valve(Abd *et al.*, 2006).

2.2.4 Lateral lines

The emitters are linked to or are part of the lateral line in some cases, the lateral lines are generally made out of plastic polyethylene and the diameter ranges between (8 to 20) mm, and it is often 14 mm(Howell *et al.*, 1980).

2.2.5 Control head

The control head valves regulate the discharge and pressure in the entire system. They may also contain filters to purify the water. Screen filters and graded sand filters that eliminate fine material suspended in the water are common filter types, a nutrient tank or fertilizer in some are existed control panels, a calculated dose of fertilizer is steadily applied to the water during irrigation. This is one of the big benefits over other types of drip irrigation (Brouwer *et al.*, 1988).

2.2.6 Emitters or drippers

Drippers are devices of small size made of high-quality plastic. They are installed in frequent spaces on soft polyethylene pipes of limited size(Phocaides, 2001). Emitters are used to regulate the flow of water from the lateral lines to the plants(Brouwer *et al.*, 1988). Emitters are devices that allow water to flow from the supply to the soil. The hydraulic characteristic of the emitters determines the rate of water flow through the emitter. Many types of emitters have been manufactured to overcome hydraulic limitations(Abd *et al.*, 2006). Based on the crop's water requirements, the number of drippers per plant, and the choice of irrigation period, the appropriate emitter discharge can be determined(Deekshithulu *et al.*, 2017).

2.3 Background History

The first experiments which led to the invention of drip irrigation system (DIS) began in Germany in 1860, where tiny clay pipes with open joints were used to combine subsurface irrigation with drainage. In the 1920s, perforated tubes were introduced, and subsequent research centered on the manufacture of perforated tubes made of various materials and the control of flow-through the holes, and the use of drip irrigation was restricted to greenhouses. The system was not feasible for field crops until the invention of low-cost plastic pipes in the early 1940s. In the late 1950s, in occupied Palestine, another significant stage in the development of drip irrigation took place, when the long-distance emitters were greatly improved. Since the 1960s, drip irrigation has grown into a significant modern form of irrigation and is used today in fields, orchards, and greenhouses. DIS is commonly used in Mexico, Japan, Europe, South Africa, Australia, and the U.S. (Keller and Karmeli, 1973).

Some of the first references in the United States of America to "trickle irrigation" can be found in Reuther's early research (1944) with the "plastic revolution" following the second world war, technological development took places on an industrial scale between (1945-1948). One of the earliest advances of commercial tomato culture occurred in greenhouses in England(Dasberg and Dani, 1999).

2.4 Advantages and Disadvantages of Drip irrigation

2.4.1 Advantages of Drip Irrigation

1.Compared to other types of irrigation systems, the trickle irrigation method is considered the best method since the method of drip irrigation offers high uniformity. Drip irrigation also has greater potential for effective use of water and fertilizers to reduce irrigation and costs of fertilizer. Trickle irrigation is important when using minimal water and fertilizers to increase nutrient intake (Sharu and Ab Razak, 2020).

2.Drip irrigation also utilizes low pressure and flow rates and helps farmers to irrigate plants more cheaply with smaller pumps and smaller, lighter tubing(Robert, *et al.*, 2005).

3. It also prevents reliable runoff and soil erosion in steep slopes or terrain areas, and lands and soils with different textures and characteristics can be adequately irrigated. The surface irrigation method does not lead to adequate efficiency, whereas drip irrigation is highly efficient(Hoseini and Delavari, 2016).

4.An expensive system is justified because drip irrigation allows for uniform application of water to plants and has an efficiency of over 90% and is more efficient to save labor and water. (Ankidawa and Zakariah, 2018a).Water conservation and high crop yields are often highlighted as essential features of a drip irrigation system (Narayanamoorthy et al., 2018).

5.Compared to other irrigation strategies such as the sprinkler irrigation system, drip irrigation methods require less energy (Ankidawa and Zakariah, 2018). This method is also acceptable for most soil types if used correctly, to avoid surface water accumulation and runoff in sandy soils, water should be used slowly in clay soils, and higher emission drainage rates are going to be required to ensure that the sides of the soil are adequately moistened (Omran, 2016).

6.Drip irrigation offers a solution where other soil treatment systems are inadequate because of a high seasonal water table, shallow dense soil layers, vegetative cover, space constraints, or other site limitations(Rowan, 2016). When drip irrigation is compared with other types of irrigation, the efficiency of water use is more than 60%, conserves water (20-60%), the requirements for fertilization are reduced (20-33), the production of crops is of high quality, and increasing yield (7-25%) (Kaushal et al., 2015).

2.4.2 Disadvantages of Drip Irrigation

1.One of the main parts of the drip irrigation system is an emitter, however, because of the narrow flow path, can cloggy with reason suspended particles, chemical deposits, and microorganisms, can be easily which can ultimately destroy the entire system (Li *et al.*, 2006; Li *et al.*, 2014).

There are three specific classes of causes of clogging emissions: physical, chemical, and biological, or organic, such as algae, sediments, bacteria, and crusts. (Abdulhadi and Alwan, 2020). The severe reduction of standardized components of a drip irrigation system is caused by emitter blockages, especially when wastewater is used for irrigation.. (Elobeid, 2006; Elamin *et al.*, 2017)

A part of the problem has been solved by the installation of filter equipment before supplying water to the system, but it has not been able to eradicate it so far, which has adverse effects on soil and crops. (Elobeid, 2006; Elamin *et al.*, 2017). Chlorination has also been shown to decrease emitters obstruction and is recommended to help prevent biofilm and slime growth(Yan *et al.*, 2010). During the irrigation process and in the case of detection of blockages, washing, acid injection, or chlorine operations, discharge of emitters should be periodically reviewed (Zamaniyan *et al.*, 2014).

2.Due to the initial cost requirements of the system drip irrigation, it's limited to large-scale implementation aspects of the economy generally restrict the use of the system of drip irrigation in areas of water scarcity and orchards and vegetables(Michael, 1978; Abd *et al.*, 2006).

3.The drip irrigation system pipes can be damaged easily by high degrees of temperature and rodents. Their major drawback is that they are should be always underground, to protect it from low or high temperatures, solar radiation, and other environmental variables (Abd *et al.*, 2006).

2.5 Operating Pressure

The water pressure in the pipes decreases due to the friction losses in the fittings and along pipes, the pressure also changes as the water flows down (pressure increase) or up (pressure loss) in the piping network (Soomro *et al.*, 2013). Hence, imprecise operating pressure leads to system failure and performance degradation, also other problems are caused by operating pressure, not static such as poor pressure regulators damaged or leaking lines and clogged emitters (Tyson and Curtis, 2009). Therefore operating pressure is critical in designing a drip irrigation system(Valipour, 2012).

2.6 Wetting patterns

Drip irrigation just moistens part of the root zone of the soil, as opposed to surface and sprinkler irrigation, moist soil is also approximately 30% less than the soil volume moistened in other ways, humidification patterns that form from distilled water to the soil depend on the type of soil and discharge (Brouwer *et al.*, 1988).

2.7 Water Quality

The yields resulting from the use of the drip irrigation system are substantially greater when water is of bad quality than those resulting from the use of other methods but their quantity remains lower than that resulting from the use of good quality. (Keller and Bliesner, 1990).

Good quality water is not always adequately available to meet agricultural industrial and domestic use requirements in the desert and semi-arid regions, therefore one of the methods for increasing the availability of water is the recycling of treated wastewater for irrigation purposes .High levels of radioactive ions and salts organic residues and heavy metals can be presented as a result of wastewater treatment. The accumulation of these substances in water and on land is, therefore a hazard to agricultural development (Abbott and Quosy, 1996).

In uneven lands, pressure regulators and pressure compensation emitters are used to obtain the best emission uniformity (EU%). However, pressure compensation emitters tend to be more expensive and complex than non-compensating emitters and are not easy to apply (Elamin *et al.*, 2017). One of the reasons for poor crop production is the poor uniformity of water application in the parts of drip irrigation systems which causes it to receive little or no water (Raphael *et al.*, 2018).

2.8 Previous Studies

Almajeed and Alabas, 2013 conducted a field study on the farm in Babylon Governorate of Iraq to improve the quality of emissions by the use of modern system layouts rather than the conventional system. The proposed system is intended to enhance hydraulic efficiency by maximizing the system's delivery pressure by linking the terminals in the subunit together, the irrigation system is operated for ten different pressures (1.5-16 m) and two types of emitter were used at the field.

Khalil *et al.*, 2020 conducted a study on hydraulic performance evaluation of locally available drip emitters used in Pakistan for nine types of emitters installed on 27 drip lateral lines. lateral line number 9 (S9) uniformity has the highest performance among all types of emitters tested (97%), while lateral line number 2 (S2) had the lowest (88%). When estimated for discharge variation under the variable head, the lateral line (S3) discharge variation was few (2%), whereas lateral line number 8 (S8) had the greatest discharge variation of 38%. Generally, the distribution uniformity was ranged from 84% to 97%.

Sharu and Ab Razak, 2020 conducted a study on modeling the compressed system of drip irrigation and the hydraulic performance. This research was performed on a small-scale greenhouse plantation in Malaysia. For hydraulic efficiency, the results of various hydraulic parameters such as the emission uniformity(EU) ,coefficient of variation(C_V), emission uniformity(EU), and the coefficient of uniformity(CU) show that they are in the excellent classification, and values of (EU) and (CU) are greater than (95%) efficiency, the value (C_V) is less than (0.03) and this means that the result is excellent. The emitter flow variation (EFV) is (10%) when the operating pressure at (15.3) m and (25.5) m and is considered desired, on the other hand for the (28.6) m and(15.3 m) operating pressures, the (EFV) parameters were registered at (13.6%) and (10.29%), respectively and classified as appropriate performance.

İncİman and Acar, 2020 conducted a study to determine the water distribution uniformity of emitters in different drip irrigation systems used in maize farms in the Kumar region of Turkey. The watering performance of drippers was classified using two criteria namely Uniformity Coefficient (UC) and Emission Uniformity (EU). UC ranged from 68% to 84% with an average of 75 % and the water delivery class was 'moderate' by that mean value. EU varied from 44% to 71% with an average of 55%, and the irrigation performance was 'poor' or 'Unacceptable' about the average value of the (EU) variations in emitter discharge rates that were found to be higher than 10% in all examined drip irrigation systems. Repair work was needed to maximize water distribution consistency.

Omofunmi *et al*., 2019 conducted a study to determine the hydraulic performance for a developed system of drip irrigation that used improved emitters for the experiment. The volumetric method was used to calculate the application rate and discharge of emitters, the emitter flow variation, emission uniformity, coefficient of variation, and coefficient of uniformity were calculated. The results indicated that standard deviation and the mean of the emitters were (0.07) L/hr. and (9.639)L/hr. respectively, the emitter flow variation was (2.5%) and less than (10%) from that was within the permissible range, while a coefficient of variation was (0.07)and less than (0.11). Coefficient of uniformity and the emission uniformity were (99.2%) and (99.4%), respectively, which indicates that the system was perfectly designed.

(Sarker *et al.*, 2019) conducted a study for a new low-pressure emitter type that was installed, developed, and evaluated using materials locally produced in two sites in Bangladesh. Average discharge of dripper of the heads of variable operating (1.5, 2, and 2.5m) with slopes of (0%, 1%, and 1.5%) were measured with a coefficient of uniformity (CU), emission uniformity (EU) and statistical uniformity (US) were determined for water applications. The central control unit for all test parameters was greater than (80%) which means that the drip irrigation system(DIS) was installed and designed with dimensions suitable for application of efficient water and distributed to individual plants with dripper performance rated and the results were categorized as fair to excellent and considering water distribution and usage. This concludes that DIS has a great opportunity to provide water.

(Amoo *et al.*, 2019) conducted a field study to evaluate the performance of drip irrigation systems for the okra production farms in southwestern Nigeria. Drip irrigation laterals were placed in between plants rows of okra with spacing emitters every (20) cm, due to the water requirements of the crops. Soil properties were studied in this research and crop water, coefficient of uniformity, uniformity of field emission due to the quality of the irrigation water and the low pressure in the irrigation systems uniformity of absolute emission and output variation coefficient. The resulting values were adequate and within the required limits for classification, the water applied to the field was more than the real demand for water of crop and the efficiency of the system of drip irrigation was (68.5) %.

Mistry *et al*., 2017 carried out experiments to obtain a discharge rate at nine different pressures (0.3-1.2) kg/cm^2. The results showed that the emitter discharge flow rate increases when the pressure increases which causes the coefficient of variance to increase, this indicates that the emitter discharge rate is affected by pressure directly. The observed emission uniformity rates at (0.3, 0.4, 0.6, 0.7, 0.9, 1.0, 1.1 and 1.2) kg / cm^2 were (79.913, 90.914, 94.040, 87.361, 90.373, 91.120, 94.546 and 94.753) % respectively for (2) L/hr., the best results were obtained for (1.2) kg/ cm^2.

Purohit *et al.*, 2017 conducted a study for field experiments to evaluate the system of drip irrigation (DIS) in horticulture and forestry college, in India .The results showed that the average application efficiency value of (85.09)% ,the average of uniformity coefficient(CU) value (93.63)%,the average emission uniformity(EU) value of (89.99)%, average distribution characteristic (DC) value of (54.06)% and average distribution uniformity value (DU)of (89.69)% for a naturally ventilated poly house (NVPH) .Average application efficiency value is (83.23)%, average of uniformity coefficient(CU) is (96.24) %, average emission uniformity(EU) is (90.45)%, average distribution characteristic (DC) value of (50.84)% and average distribution uniformity value (DU) of (88.07)% for open environment (OE), in each case design criteria of (90) %.

Zamaniyan *et al.*, 2014 conducted a study for field performance of systems of micro-irrigation in ten sites in Iran, physical, chemical, and biological examinations of samples of water were obtained from each site. In this research, following parameters were calculated statistical uniformity (Us), emission uniformity (EU), coefficient of variance due to performance of emitter in the field (VPF), sector emission uniformity (EUs), and absolute uniformity emission (EUa).The results showed that the performance of the system of micro irrigation was poor and low. The average (Us), (VPF) and (EU) values in various sites were (61.3), (38.2), and (52.8) percent respectively. The most frequent problems identified in irrigation systems were clogging of emitters, insufficient working pressure and lack of training for farmers.

Elamin *et al.*, 2017 conducted a study in the agriculture college, Khartoum University to evaluate the hydraulic performance systems of drip irrigation. The study consisted of three kinds of emitters (Octa, barrel, and turbo) by three pressures of operating (P1=1, P2=0.75, and P3=0.5) bar, the following parameters were calculated: emission uniformity (EU%), coefficient of variation(CV %), coefficient of uniformity(CU %), and studied percentage clogging. The results showed that the emitter of turbo and pressure of operating (P1) are more suitable for improving drip irrigation hydraulic efficiency and resisting clogging, the type of emitter and the operating pressure is strongly influenced by the clogging percentage of drip emitters. Whereas, irrespective of the emitter styles, the percentage of emitter clogging decreased as operating pressure increased.

Abdulhadi and Alwan, 2020 conducted a study to assess the performance systems of drip irrigation in Fadak farm in holy Karbala city in Iraq. In this study the results for the drip irrigation system indicated 96.5% for field emission uniformity ,96.25% for absolute emission uniformity,95.9% for design emission uniformity ,97% for statistical uniformity coefficient ,6.85% for emitter flow variation ,0.026 for a coefficient of variation ,96.5% for application efficiency, and 16.98% for pressure variation. Drip system performance was graded as excellent.

Ankidawa and Zakariah, 2018a conducted a study that evaluated and designed a system of drip irrigation for date palm farms in Northeastern Nigeria. The drip irrigation system was built, installed, and tested on an area of 400 m^2 in the studied region using locally available materials. The outcome of the study of the particle size indicates that the soil type varies from sand to sandy loam which is suitable for the Date Palms. The water application uniformity was above 90%. This indicates that the drip irrigation system was well established.

Narayanamoorthy *et al.*, 2018 conducted a study to assess the effect of the economy of drip irrigation on vegetables production in India. The pringle plant which is a vegetable widely planted and consumed in the region was selected. The results showed that in addition to water and energy savings, drip irrigation decreased fertilizer usage by 31% and raised the yield of crops by 52%.

Azizi *et al.*, 2013 conducted a study for evaluation of drip irrigation as a case study on the Babol Province in Iran. Ten orchards were chosen as a sample in different areas of Babol province with different water and soil conditions and were studied to assess and examine the problems facing drip irrigation systems. Due to lower water pressure and emitter blockages, the study showed emitter discharges in all these ten orchards were much lower than planned amounts. Emission uniformity was lower than 90% of the required requirements. Due to the consistency of the irrigation water and the low pressure in the irrigation systems, the average emitter discharge in the studied orchards was lower than the required amount.

2.9 Summary

By reviewing the previous research's that was reviewed in this chapter to evaluate drip irrigation systems, where more than emitter and lateral line were used, and was calculated the values of efficiency of application, emission uniformity, coefficient of variation and statistical uniformity, variation of emitter flow rate and pressure head variation. In this research, the same special coefficients were calculated in the evaluation of drip irrigation systems, and was noted that the coefficient values of the local product decreased, so the value of C used in each product was deduced by calculating the value of the pressures using Hazen William's equation and comparing it with what was measured in the field, It was found that local products use a value of C is 140 and the imported product is 150, maybe this the reason for the low efficiency of the local product. A program was also used to re-design part of an existing farm and compared the design of the program with used in the farm.

CHAPTER THREE

THEORETICAL ASPECTS

3.1Introduction:

Trickle irrigation is a system for water supply after filtering and occasionally adding fertilizer directly into or onto the soil, Clogging leads to poor distribution along the sides, and it may take time before they are discovered and cleaned or repaired at times, and thus poor distribution along the sides of the watering of the plants (Merriam and Keller, 1978). Therefore, it is necessary to study and evaluate these systems with a hydraulic study and calculate the important parameters in the evaluation.

3.2 Field Evaluation

Experiments in the field were evaluated using the following terms:

3.2.1 Efficiency of Application

Application efficiency: is the proportion of need for water in the root zone to total water consumed, it can be calculated by the following equation(Jamrey and Nigam, 2017).

$$Ea = \frac{q_{min}}{q_{ave}} * 100 \qquad 3.1$$

Where, Ea= application efficiency, %. q_{min}= minimum discharge of emitter L/h, q_{ave}= average discharge of emitter L/h.

3.2.2 Emission Uniformity (EU):

To assess whether the system is operating with appropriate efficiency, the emission standardization was assessed by calculating with this formula:

3.2.2.1 Emissions Uniformity in Field (EU_f)

$$EU_f = \frac{q_{\frac{1}{4}}}{q_{ave}} * 100 \qquad 3.2$$

Where:

EU_f = uniformity of field emission (%),

$q_{\frac{1}{4}}$= average of the lowest quarter of the flow rate of the emitter (l/h)(Ortega *et al.*, 2002). established the following ranges of (EU) values and their interpretations that are mentioned in Table3.1 (Merriam and Keller, 1978).

Table 3.1: Classification according to values of emission uniformity (Merriam and Keller, 1978).

EU, %	Category
> 90	(Excellent)
80-90	(Good)
70-80	(Acceptable)
< 70	(poor)

3.2.2.2 Uniformity of Absolute Emissions (EU_a).

The following equation was used to determine the uniformity of absolute emissions(Ortega *et al.*, 2002).

$$EU_a = 100 \left[\frac{q_{\frac{1}{4}}}{q_{ave}} + \frac{q_{ave}}{q_X} \right] * \frac{1}{2} \qquad 3.3$$

Where,

EU_a = Absolute emission uniformity,

q_X = Average of the highest 1/8 of the emitters flow rate (l/h)

3.2.2.3 Uniformity of Design Emission (EU_d)

The uniformity of design emission was calculated by using the following equation(Merriam and Keller, 1978).

$$EU_d = 100 * \left[1 - \frac{1.27 C_V}{\sqrt{N}} \right] * \frac{q_{min}}{q_{ave}} \qquad 3.4$$

Where: $EU_{d=}$uniformity of design emission, (%),

C_V= variation coefficient, N=number of emitters, q_{ave}= average discharge of emitter (l/h), q_{min}=minimum discharge of emitter (l/h).

3.2.3 Coefficient of Variation (C_v) and Statistical Uniformity

Variation coefficient is the parameter that is usually used as a measure of the change in the emitter flow caused by the difference in the emission device's manufacturing properties(Asif *et al.*, 2015).

Variation coefficient is the relationship between the standard deviation to the mean. The coefficient of variation is used for comparing the differences in two or more data sets (Soomro *et al.*, 2013).

$$C_v = \frac{S_q}{q_{ave}} \qquad 3.5$$

Where ‘Sq’ is the standard deviation of flow.

'q_{ave}' is the mean flow for a sampled number of emitters of the same type tested at a fixed pressure and temperature (20 °C). (Asif *et al.*, 2015)

(Solomon, 1979) established the following ranges of (C_v) values and their interpretations that occasion Table 3.2.

Table 3.2: Classification of coefficient of variation (Solomon, 1979)

coefficient of variation(C_v)	Category
Less than (0.1)	(Excellent)
(0.2-0.1)	(Very good)
(0.3-0.2)	(Acceptable)
(0.4-0.3)	(Low)
Over (0.4)	(unacceptable)

Statistical uniformity was also calculated by Equation 3.6.

SUc =100(1- *C*v) 3.6

Where, SU_c =statistical uniformity coefficient. The limits and classifications of (*C*v) values and their interpretations are shown in Table 3.3.

Table 3.3: Classifications according to Statistical uniformity values (Mistry *et al*., 2017).

Statistical uniformity (SU_c)	Category
over 90%	(Excellent)
80-90	(very good)
70-80	(Fair)
70 - 60	(Poor)
Less than 60%	unacceptable

3.2.4 Variation of Emitter Flow Rate (q_{var})

Emitter flow rate variation was calculated by using the following equation

$$q_{var} = 100 * \left[1 - \frac{q_{min}}{q_{max}}\right] \quad 3.7$$

Where: q_{var} is the variation of emitter flow rate, q_{max} is the maximum discharge of emitter, l/h. The limits and classifications of (q_{var}) values and their interpretations are presented in Table 3.4.

Table 3.4: Classifications according to variation of emitter flow rate values (Pragna, 2017).

Variation of emitter flow rate(q_{var})	Category
above 25%	not acceptable
(10 – 20) %	acceptable
Less than (10) %	desirable

3.2.5 Pressure Head Variation (h_{var}):

pressure head variation (h_{var}) is defined as

$$h_{var} = \frac{h_{max-}\ h_{min}}{h\ _{max}} \qquad 3.8$$

Where:h_{max} and $h_{min}$are the maximum and minimum pressure heads respectively, along the lateral lines. In drip irrigation design, the maximum pressure variation allowed is 20% as stated by (Michael, 1978).

3.3 Hydraulics evaluation of trickle irrigation lines:

Trickle irrigation lines have a spatially varying, hydraulically steady flow of pipe with lateral drip outflows, total discharge a trickle irrigation, whether lateral, submain, or primary decreases as the line length increases(Abd *et al.*, 2006). Usually, the mainline in the system is designed based on the required pressure, input pressure, and the slope of the energy gradient line and this going to give a total energy output greater than that needed for irrigation at any sub main (Howell *et al.*, 1980).

One of the most complicated aspects of lateral hydraulics in drip irrigation is in calculating an accurate friction factor estimate, *f*, the variation of (f) along the lateral caused by changing in discharge for location causes this issue(Thompson, 2009).

Drip irrigation lateral or manifold pipe flow can be hydraulically steady or spatially varied pipe flow, this indicates that the total flow through the pipe varies with a length generally decreasing along the pipe. The pressure distribution or energy gradient line is also changing normally in a downward direction as a result of friction and elevation, Figure (3.1) represents a drip irrigation lateral line's flow and pressure distribution. Any one of several empirical equations can be used to measure head loss due the friction if drip irrigation pipes are assumed to be hydraulically smooth, the first equation using the Darcy-Weisbach equation(Bralts *et al.*, 1987):

$$H_f = \frac{LV^2 f}{2gD} \quad 3.9$$

H_f = head loss due to friction in m, f = friction factor, L = Pipe length in m,D = Diameter of the pipe in m, V = velocity of water(m/s),g= acceleration of gravity (m/s^2).

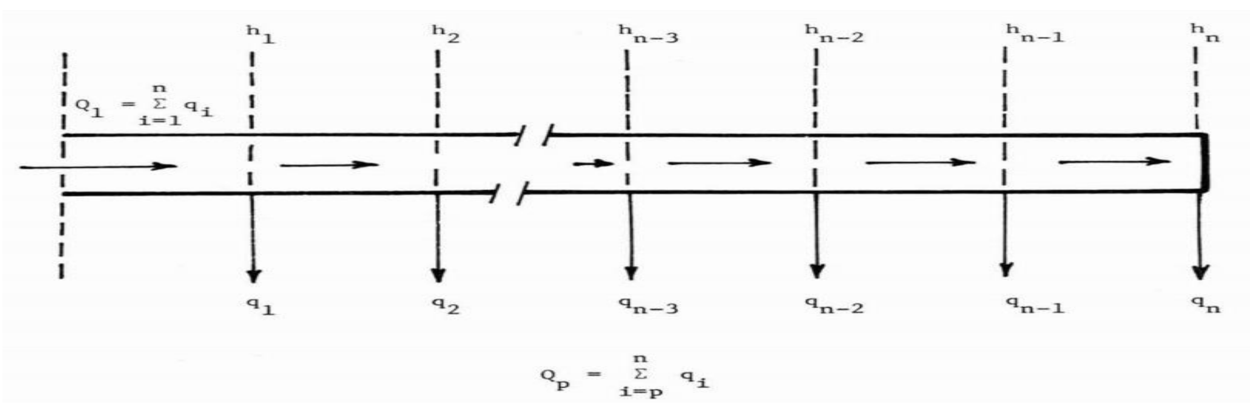

Figure 3.1: The distribution pressure and flow along a trickle irrigation lateral line(Howell and Hiler, 1979).

Over there are two Species of head losses that made up a result of flow water in manifolds minor and major head losses. Losses due to valves, fittings, elbows, and a change in pipe geometry (sudden contraction or expansion) are minor losses while friction head losses in manifolds are known as a major loss(Mostafa, 2015). The flow in drip laterals is typically turbulent except for some sections in the downstream end of the lateral flow probably laminar (Valiantzas, 2005)For pipe water flow, the friction drop equation can be expressed simply.

$$\Delta h=\Delta L\ aQ^{m} \qquad 3.10$$

Where: Δh: cumulative low of energy of section of a pipe and it is constant for a given pipe type and size of the flow; Q: rate of discharge, in(L/s); ΔL: section length, m, m =(1)for the flow of laminar, m = (1.75) for the flow of turbulent in a smooth pipe, m = (1.85) for the flow of turbulent and m = (2) for the flow of a fully turbulent using the Hazen Williams formula, (Howell and Hiler, 1979).

Using the Blasius empirical formula for smooth pipes with turbulent flow to describe friction factor.

$$f = \frac{0.3164}{(R_e)^{1/4}} \qquad 3.11$$

Equation 3.12 is regarded as valid for ($4000 \leq R_e \leq 100000$) in full flow in circular pipes.

Where: R_e = Reynolds number.

The friction factor for the transition region can be approximated by(Abd *et al.*, 2006):

$$f = 3.42\text{x}10^{-5} R_e^{0.85} \quad (2000 \leq R_e \leq 4000) \qquad 3.12$$

The empirical equation that is also often used in hydraulic design is the Hazen-Williams equation(Allen, 1996):

$$H_f = 1.21*10^{10} \left(\frac{Q^{1\cdot852}}{C^{1\cdot852}D^{4\cdot871}}\right)L \quad 3.13$$

where: C = pipe roughness coefficient.

Q= Flow rate in L/s, D: pipe diameter in mm.

If a C value of 150 for smooth pipe is substituted into Eq. (3.20) we obtain the following empirical equation

$$H_f = 11.29*10^{5} \left(\frac{Q^{1\cdot852}}{D^{4\cdot871}}\right)L \quad 3.14$$

Where: Q= Flow rate in L/s, D: pipe diameter in mm and *C* value of the Hazen-Williams factor seemed dependent upon pipe diameter for drip irrigation systems were suggested to be as follows:

C = 130 for (14 to 15mm) (0.59-in.) plastic pipe, *C* = 140 for (18 to 19mm) (0.75-in.) plastic pipe , *C* = 150 for (25 to 27mm) (1-in.) plastic pipe (Howell *et al.*, 1980).

One of the challenges in drip irrigation lateral hydraulics is to find an accurate estimation of friction factor, f, as using in the Darcy-Weisbach equation to find out hydraulic head loss in the lateral, this is because the discharge varies depending on the location(Mostafa, 2015). Keller and Bliesner, 1990 and several previous studies suppose the coefficient of friction, *f*, along the ramified constant. While, Mohamed *et al.*, 2021 showed that the coefficient of friction varies depending on a variety of pipe characteristics such as diameter, pipe wall roughness, kinematic viscosity, and water flow velocity.

If a trickle irrigation line is put on the level land variation of pressure along the line that is going to follow the curve of the energy gradient, if it is put on slopes, the variation of pressure is going to be affected by the slopes. When the line is put downslope, it goes to gain pressure and when the line is put upslope it goes to lose pressure. The gain or loss in pressure is linearly proportional to the line length and slope, the total of energy at any section of a line of drip can be determined by the equation of the energy (Howell and Hiler, 1979). For various flow conditions, the energy gradient lines are shown in Figure (3.2).

$$H = h + Z + \frac{v2}{2g} \qquad 3.15$$

where H is the total energy, in m; z: elevation head, in m; h: pressure head, in m and $v^2/2g$: velocity head in m.

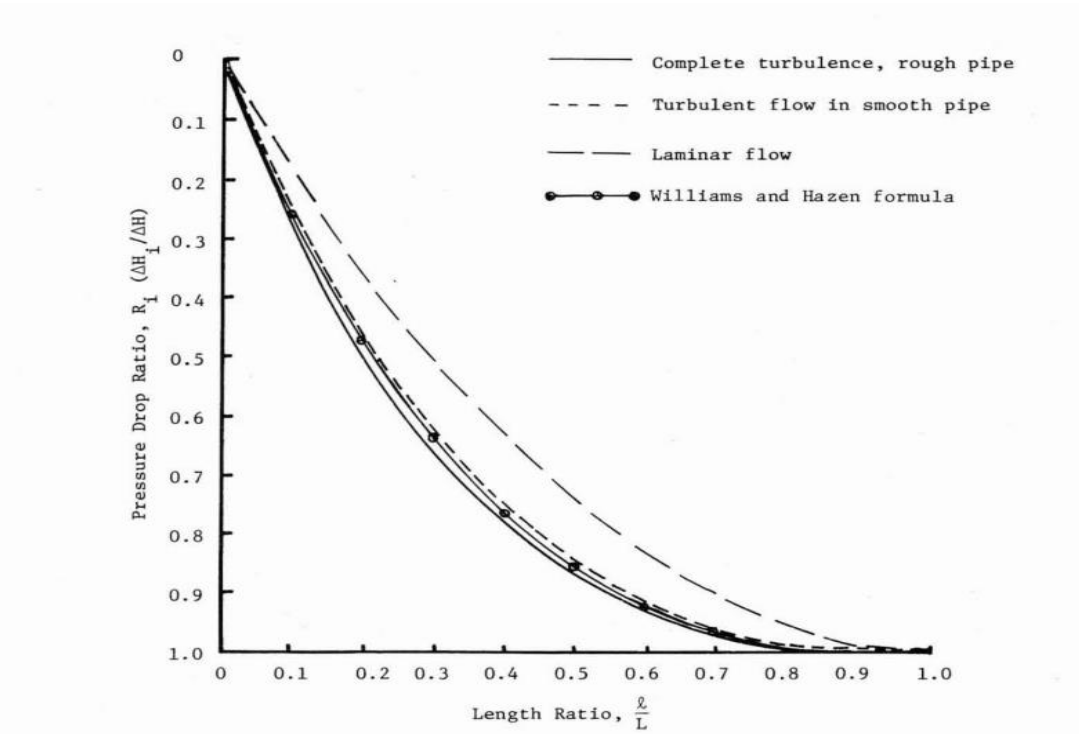

Figure 3.2. Curves showed the friction drop pattern caused by laminar flow, flow in a smooth pipe, and complete turbulent flow in a lateral line(Howell and Hiler, 1979).

3.4 Correction Factor for Manifold and lateral

3.4.1 Correction Factor for Lateral or Manifold of Constant Diameter and Varying Velocity

Manifold and lateral are hydraulically similar, manifold outlets are located at lateral locations, while, lateral outlets are located at dripper locations. The derivations where done by (Mostafa, 2004) for manifold and lateral showed that both are similar in applying the factor of correction, F_1, derived by applying the equations of Darcy -Weisbach and Hazen -Williams are nearby to not only each other but as well to those specified by Christiansen(Christiansen, 1942), to appreciate the correction factor, F1, (Oron and Walker, 1981) the following equation is given:

$$F_1 = 0.63837\ n^{-1.8916} + 0.35929 \qquad 3.16$$

where: F1 = correction factor, n = outlets number on a specific pipe.

The correction factor is given also by Christiansen in the following equation(Christiansen, 1942):

$$F_1 = \frac{(b+1)^{-1} + (2n)^{-1} + (b-1)^{0.5}}{(6n^2)} \qquad 3.17$$

where b is the exponent of velocity or flow in the head loss equation, n = outlets number.

The factor of correction according to the formula found by Hazen-Williams is in the following equation(Mostafa, 2004):

$$F_1 = \frac{[\,(n)^{c3} + (n-1)^{c3} + (n-2)^{c3} + \ldots\ldots (n-(n-1))^{c3}\,]}{[(n)^{c3+1}]} \qquad 3.18$$

Where :(n-(n-1)) => 1, C3 = 1.852 and n = outlets number.

The factor of correction according to the formula found by Darcy-Weisbach in the following equation(Mostafa, 2004):

$$F_1 = \frac{[(n)^2 + (n-1)^2 + (n-2)^2 + \text{.........}(n-(n-1))^2]}{[(n)^3]} \qquad 3.19$$

where, (n-(n-1)) => 1 and n = outlets number.

3.4.2 Correction factor for manifold or lateral of varying diameter and constant velocity.

Changing the pipe diameter is more suitable for both manifold and/or lateral design in sprinkler irrigation than drip irrigation, where the outlet spacing is comparatively protracted and the discharge is of big value.

The factor of correction according to the formula found by Hazen-Williams is determined by the following equation(Mostafa, 2004).

$$F_2 = \frac{[(n)^{c6} + (n-1)^{c6} + (n-2)^{c6} + \text{.........}(n-(n-1))^{c6}]}{[(n)^{c6+1}]} \qquad 3.20$$

where, (n-(n-1)) => 1 and C6 =-0.58.

The factor of correction according to the formula found by Darcy-Weisbach is in the following equation(Mostafa, 2004).

$$F_2 = \frac{[(n)^{-0\cdot5} + (n-1)^{-0\cdot5} + (n-2)^{-0\cdot5} + \text{.........}(n-(n-1))^{-0\cdot5}]}{[(n)^{-0\cdot5+1}]} \qquad 3.21$$

where, (n-(n-1)) => 1

3.5The statistical error indices:

The Root Mean Square Error (RMSE): is a commonly used metric for comparing the values predicted by a model to the values seen in the field. The RMSE aggregates these individual variations into a single measure of predictive capability.

$$RMSE=\sqrt{\frac{\sum_{i=1}^{n}(Xobs,i-Xmod)^2}{n}} \quad 3.22$$

Xobs is the observed value in field, Xmod is the design value, n is number of emitters

The mean bias error (MBE): is primarily used to estimate the average bias in the model and determine whether any efforts to fix the model bias are required. The average bias in the forecast is captured by MBE. The lower values of errors and considerably higher value of correlation coefficient for the variable and direction are of greater importance.

$$MBE=\frac{1}{n}\sum_{i=1}^{n}(Xmod,i-Xobs,i) \quad 3.23$$

The mean absolute percentage error (MAPE): is a measure of prediction accuracy of a forecasting method in statistics. The MAPE measures the size of the error in terms of percentage. It is calculated as the average of the unsigned percentage error.

$$MAPE=100*\frac{1}{n}*\sum_{i=1}^{n}(\frac{Xobs,i-Xmodl,i}{Xobs,i}) \quad 3.2$$

CHAPTER FOUR

FIELDWORKS

4.1 Introduction

Drip irrigation is the slow and controlled application of water to plant root areas through spaced emitters and at specified intervals (Opar *et al.*,2014).Water is supplied directly to plant roots with low pressure and flow rate to meet the crop water requirements(Elamin *et al.*, 2017). High potential application quality, the addition of chemical fertilizers with irrigation water, cultural operations during irrigation, energy savings are among the benefits of the drip irrigation technique. There is a great demand from farmers for the drip irrigation system in the desert areas in Iraq.

4.2 Study Area

The experiments were carried out on farms in the holy Karbala province in Iraq located on the road linking Karbala Governorate, and Najaf Governorate, east of the holy city of Karbala, in private farms for growing vegetables such as tomato, cucumber, eggplant, pepper ....etc. The location map is shown in Figure (4.1).

Figure 4. 1 Geographic location area of study according to the Iraqi map.

4.3 Physical Soil Properties

To be able to know some physical information of the soil in the farms that use the drip irrigation system, the following tests were carried out. Some of these experiments were carried out on-site, and others were conducted in the laboratories of the Faculty of Engineering, University of Karbala.

4.3.1. Laboratory Experiments.

4.3.1.1 Dry Density

Three soil samples were taken from the experimental block using a core sampler of known volume (728.48 cm3) for bulk density test. The samples were then placed in plastic containers to prevent loss of moisture before being sent to the laboratory for processing. Dry density was determined using the equation (4.1). Table 4.1 shows the calculation of dry density.

$$\gamma = \frac{w_s}{v} \qquad 4.1$$

Where: γ = dry density, gm/cm^3

w_s = the dry weight of the sample, gm.

$\boldsymbol{v}$ = the volume of the core sample, cm^3

Table 4.1 the calculation of dry density.

No of samples	Dry weight(g)	volume(cm^3)	Bulk density (g/cm^3)
1	1321	728.48	1.813
2	1250.5	728.48	1.717
3	1049	728.48	1.440
Average			1.657

4.3.1.2 Specific Gravity (Gs)

Soil samples for dry density determination have also been used to assess the specific gravity. The specific gravity was determined using the formula below. Relevant gravity values are calculated according to the standard specification requirement ASTM D854-14.

$$Gs = \frac{ws}{B + \text{soil weight} - A} \qquad 4.2$$

Where: Gs = The Specific gravity

B= weight of the pycnometer with water only, gm.

A = weight of pycnometer with water and soil, gm.

Table 4-2: The specific gravity of the soil.

Sample No.	Sample weight(gm.)	A (gm.)	B (gm.)	Gs
1	9.92	109.31	103.06	2.703
2	9.95	109.41	103.04	2.79
3	9.98	109.04	103.04	2.508
Average				2.663

4.3.1.3 Particle Size Distribution Analysis

Three soil samples were taken, where the samples were first passed on sieve No. (4), and the passing quantity on sieve No 4 was washed on sieve No.200. The gradient test was conducted for coarse grains of more than 2 mm. The measured particle sizes of the soil include silt, sand, and clay, and this was accomplished by the following method, and according to the standard specification ASTM-D422.

- 500 grams was taken from the passed amount from sieve No. 4, and each sample was washed on sieve number 200, the remaining sample was taken on sieve number 200 and placed in the oven to dry.
- After that, the samples were weighed and placed in a set of arranged sieves, the sieves were placed on vibrators for 10 minutes and then weights were taken.
- The residue on each sieve was taken to find the granular gradient. Table (4.3) and Figure (4.2) show percentage of the passage %.
- To accomplish the granular gradient of the passage of part of sieve No. 200, a hydrometer examination has been performed.
- 50 g of dry and transit soil were taken from soil passing sieve no.10 in 500 ml flask. Fifty 50 ml of (5%) sodium hexametaphosphate was added. The distilled water of (100 ml) water was also added.
- The sample in the flask was shaken for regular periods for making a homogeneous solution.
- The Pre-mentioned soil sample solution was moved to a1000 ml glass cylinder and the solution 1,000 ml was prepared by adding water (Figure 4.3).
- Then the solution is left for 24 hours, after which readings are taken for the following times. Table (4.4) shows the hydrometer and the thermometer reading for the samples of soil.

After the completion of sieve and hydrometer analysis, the percentage of the three types of granular size of the soils is shown in Table (4-6).

Table 4- 3: Percentage of passage%.

sieve No.	Sieve diameter mm	percentage of passage %		
		Sample1	Sample2	Sample3
4	4.75	100	100	100
10	2	98	98.7	98
20	0.84	91	93.6	90
40	0.425	65.6	65.3	68.6
60	0.25	32.1	39.3	41.2
100	0.15	14	14.3	13.8
200	0.075	0.7	2	0.4
pan	0	0	0	0

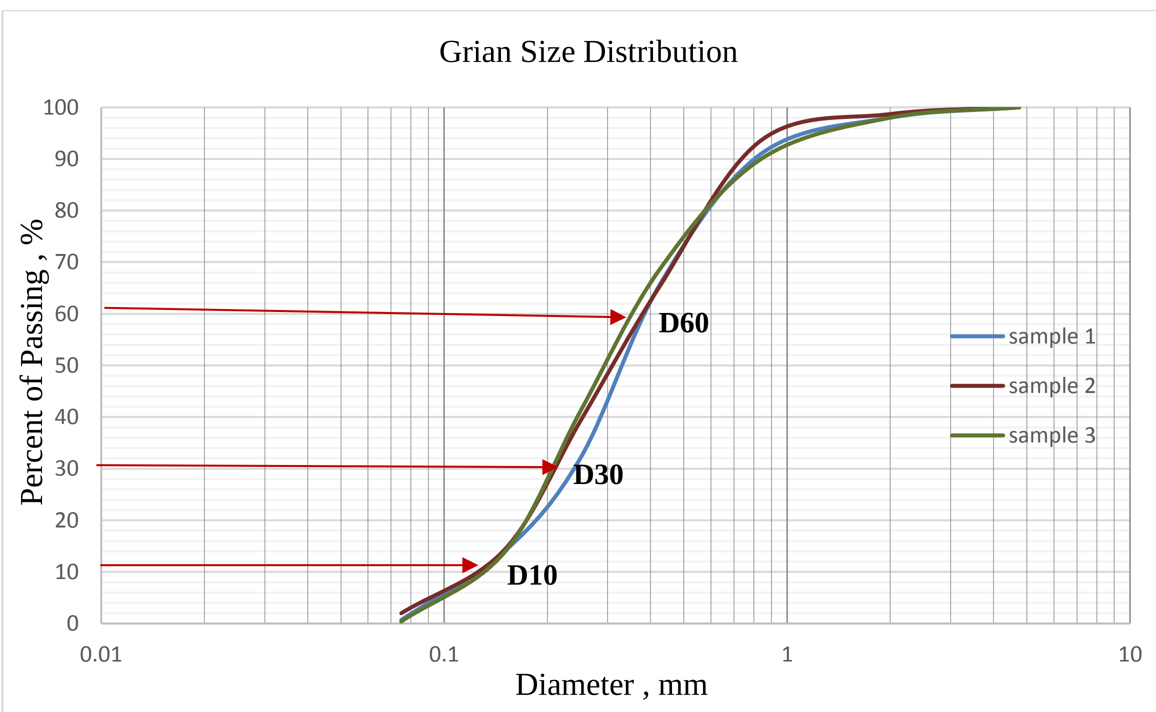

Figure 4-2: Grain size distribution.

Figure 4-3: The particle size analysis in the laboratory.

Table 4-4: Hydrometer and thermometer reading.

Tim, min	Temperature C°	Depth, mm		
		Sample 1	Sample 2	Sample 3
0.5	21	50	32	34
1	21	45	31	33
2	21	41	30.5	32
4	21	38	30	31.5
8	21	32	28	30
15	21	30	26	28.5
30	21	27	24	26.5
60	21	22.5	22	24
120	21	19	20	21
1440	20	11	12	10

Table 4-5: The percentage of fine materials.

Sample 1		Sample 2		Sample 3	
Adjusted finer P_A	Diameter (mm)	Adjusted finer P_A	Diameter (m)	Adjusted finer P_A	Diameter (mm)
0.62	0.057	1.03	0.0640	0.238	0.0689
0.55	0.0422	0.997	0.0450	0.230	0.0491
0.50	0.0308	0.977	0.0320	0.222	0.035
0.46	0.0211	0.950	0.0218	0.210	0.0236
0.37	0.0156	0.880	0.0156	0.205	0.0168
0.35	0.01157	0.800	0.0115	0.193	0.0124
0.30	0.00836	0.720	0.0083	0.170	0.0089
0.238	0.00610	0.640	0.0059	0.155	0.0064
0.19	0.00440	0.570	0.0042	0.130	0.0046
0.08	0.00134	0.250	0.0013	0.037	0.0014

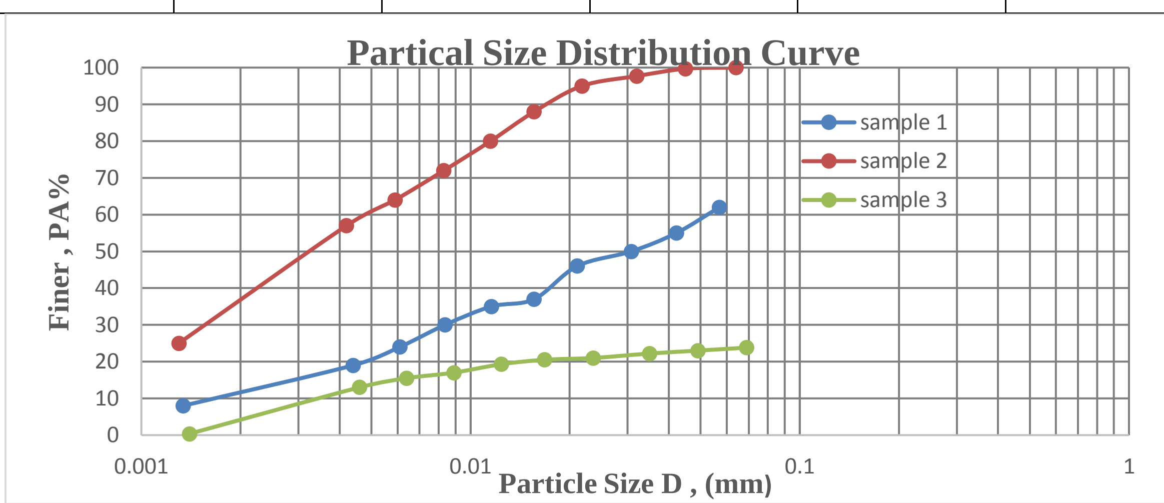

Figure 4- 4: Relationship between the diameter of the granules and the proportion of fine materials.

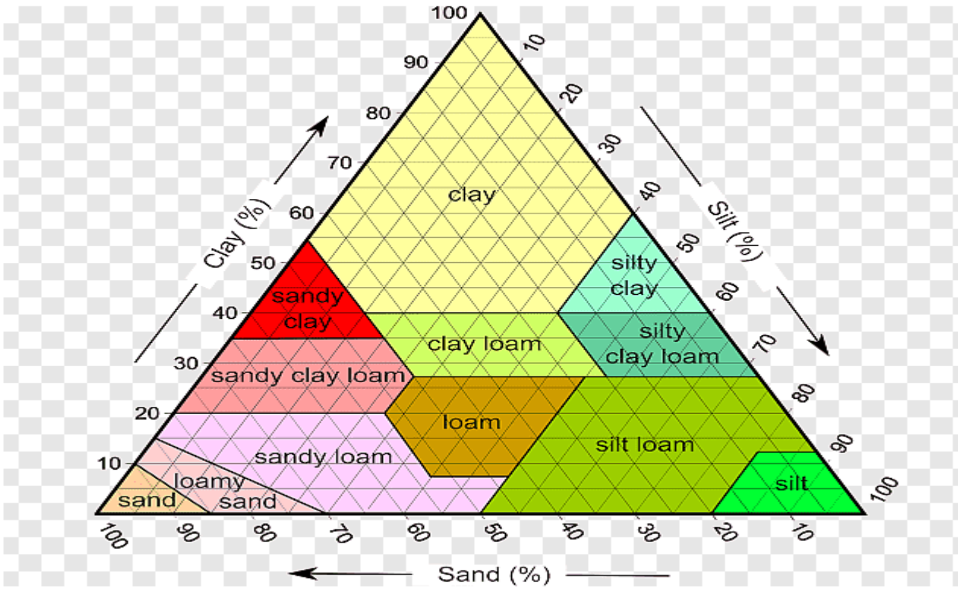

Figure 4- 5: Soil textural triangle (USEPA, 2003).

Table 4-6: Ratios of soil components.

Soil	Sample1 %	Sample2 %	Sample3 %
Sand	97.5	98.4	98
Silt	0.197	0.2	0.225
Clay	0.0013	0.0013	0.0014

Table 4- 7: Soils type.

Sample	1	2	3
Soil type	sand	sand	sand

4.3.2 Site Measurements

4.3.2.1 Measurements of System Performance Parameters

To evaluate the irrigation systems used and produced locally, three types of irrigation pipe systems were selected, two of which are locally produced in the city and its suburbs, while the third is imported of Jordanian origin. These three types are the most used, as for the emitters, two types were used in the Karbala city farms. In addition, a main pipe and a pump were equipped. The pump was installed on a well. The irrigation system was consisting of six irrigation laterals in the first experiment with two lateral pipes for each product 25 meters long for each lateral with a diameter of 16 mm made high-density polyethylene plastic, the distance between the emitters was 30 cm in the first experiment the number of emitters in each lateral line was 82 as shown in Figure (4.8) for emitter No1 and Figure (4.6,4.7)) for the irrigation network used in the study.

As for the second experiment, another type of emitters was used emitter on the distribution lateral line directly and non-pressure compensating as shown in Figure (4.9) for emitter No2, at a distance of one meter between the emitters, the number of emitters in each lateral line was 25. The irrigation system was consisting of three irrigation laterals line 25 meters long for each lateral with a diameter of 16 mm made high-density polyethylene plastic and with a lateral pipe one for each product, each time the discharge of the well water coming out of the emitters was measured by collecting the water in a plastic container within one minute, Figure(4.11).

The pressure was measured in each emitter and the measurements were made through three operating pressures, which are (0.6, 0.8, 1) bar in the first experiment and using emitter No 1 shown in Figure 4.8, and data for the first experiment are shown in Tables(C1.1,C1.2,C1.3,C2.1,C2.2,C2.3,C3.1,C3.2, and C3.3) in appendix C. Operating pressures, which are (0.5,1, 1.5) bar in the second experiment using emitter No 2 shown in Figure 4.9 and data for the second experiment are shown in Table 4.8 and Tables (C4 and C5) in appendix C.

In one of the existing farms in Karbala (agricultural development farm subordinate holy Hussaini shrine administration), a drip irrigation system was used, with two different types of drippers (GR and T-Tape) as shown in Figures (4.10,4,11) at a distance of 40 cm and 10 cm respectively. Drippers were characterized by being within the lateral pipe and could not be separated from the lateral line. Discharge out of the drippers was measured in the same way as the previous one as shown in Figure (4.11). Pressure measurement was neglected because could not be measured because the emitter used in the farm was an integral part of the lateral pipe in the experiments that have been carried out according to(Merriam and Keller, 1978) and data for the experiment are shown in Tables(4.9A,4.9B,4.10A, and 4.10B).

Figure 4-6: The drip network implemented for the purpose of the study.

T-Tape : These special tubes are characterized by a prepared distillation system inside them, which starts with a filter to purify the water reaching it, then moves to more accurate filters before it comes out in the form of drops to feed the crops to filter them from any unwanted micro impurities. In addition, it has predetermined and scientifically studied distances according to the type of crop to give the best results during the distillation stage.

GR: It contains a cylindrical drip attached to the surface of the inner wall of the pipe, and it has a relatively wide path that causes turbulent water flow, which reduces the possibility of blockage of the dripper due to plankton in the irrigation water. It is often used to irrigate vegetables in open fields and indoors, and it can be used to irrigate trees.

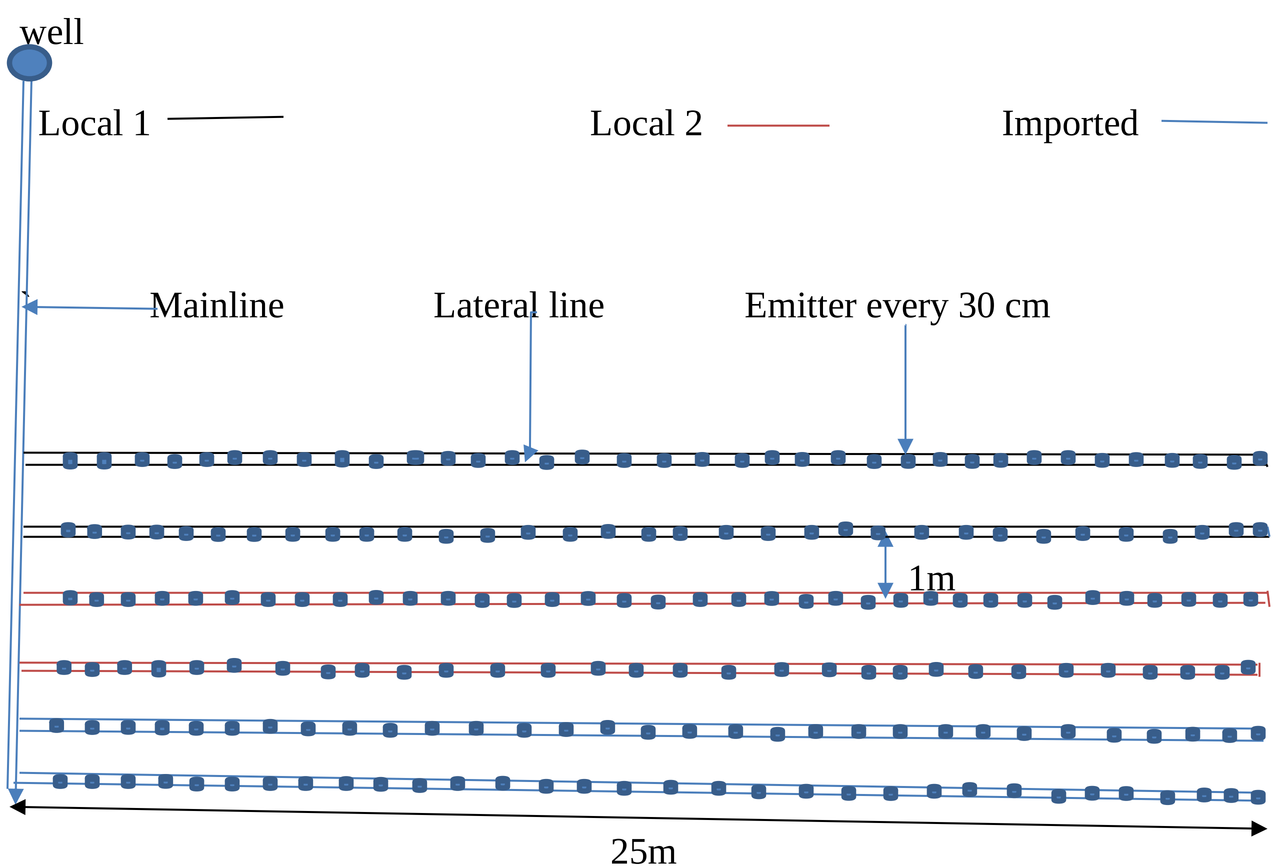

Figure 4-7 Show the drip irrigation pipe network that was implemented.

Figure 4- 8 Emitter No.1

Figure 4- 9 Emitter No.2

Figure 4-10 Emitter T-Tape.

Figure 4-11 Emitter GR.

`

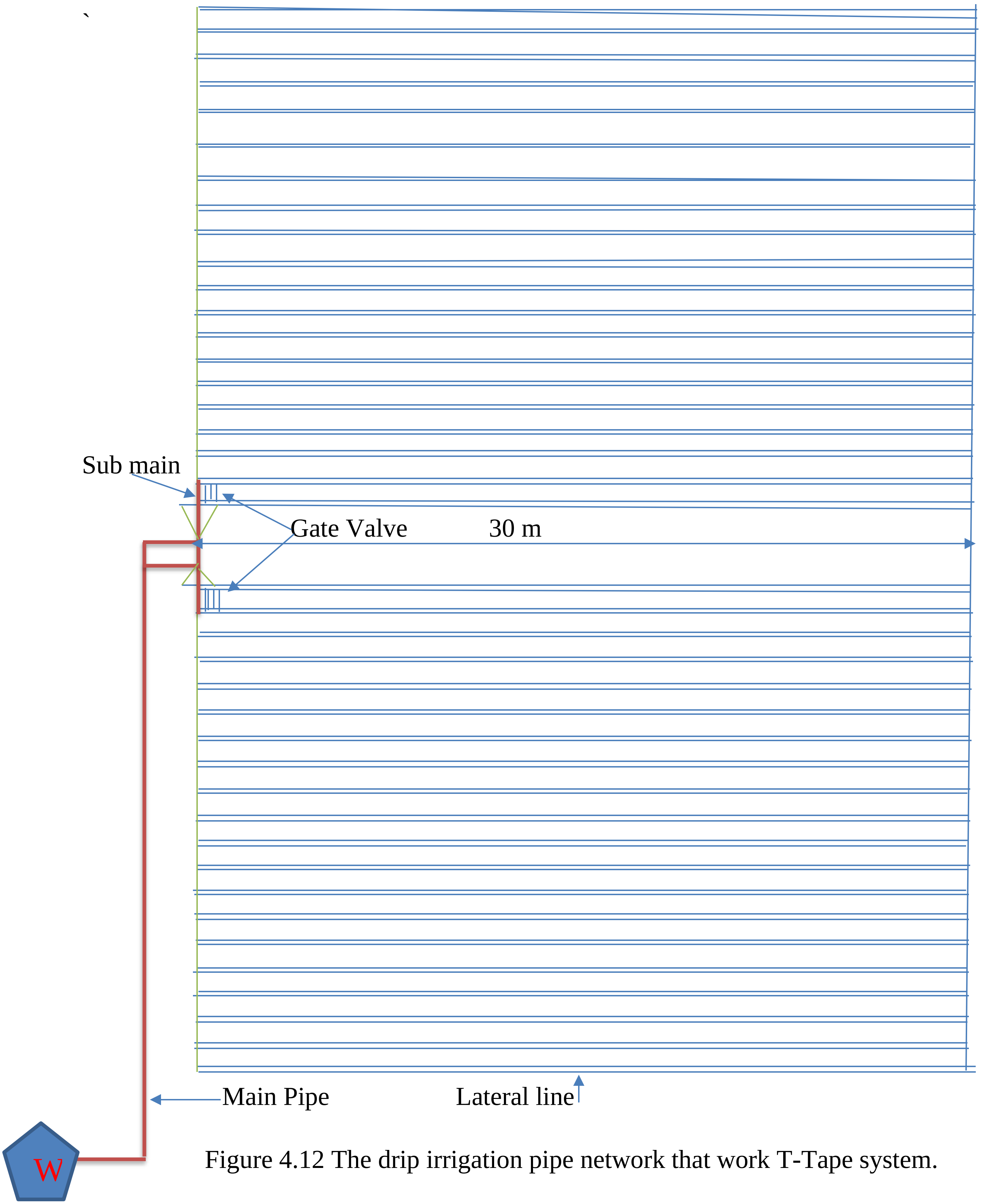

Figure 4.12 The drip irrigation pipe network that work T-Tape system.

Table 4-8: The measured flow rate of emitter type two under the pressure of 1 bar.

Type of lateral	No. emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
Local 1	1	630	1	630	37.8
	5	570	1	570	34.2
	9	540	1	540	32.4
	12	510	1	510	30.6
	15	490	1	490	29.4
	18	470	1	470	28.2
	21	460	1	460	27.6
	25	440	1	440	26.4
Local 2	1	640	1	640	38.4
	5	610	1	610	36.6
	9	590	1	590	35.4
	12	580	1	580	34.8
	15	560	1	560	33.6
	18	530	1	530	31.8
	21	510	1	510	30.6
	25	490	1	490	29.4
Imported	1	640	1	640	38.4
	5	620	1	620	37.2
	9	600	1	600	36
	12	598	1	598	35.88
	15	595	1	595	35.7
	18	570	1	570	34.2
	21	555	1	555	33.3
	25	540	1	540	32.4

Table 4-9A: The measured flow rate of emitter type T -Tape.

lateral line. No	No. emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	25	1	25	1.5
	4	25	1	25	1.5
	8	24	1	24	1.44
	12	25	1	25	1.5
	16	24	1	24	1.44
	20	23	1	23	1.38
	25	23	1	23	1.38
	30	23	1	23	1.38
2	1	23	1	23	1.38
	4	23	1	23	1.38
	8	23	1	23	1.38
	12	23	1	23	1.38
	16	22	1	22	1.32
	20	22	1	22	1.32
	25	21	1	21	1.26
	30	21	1	21	1.26

Table 4-9B: The measured flow rate of emitter type T -Tape.

lateral line. No	No. emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
3	1	25	1	25	1.5
	4	25	1	25	1.5
	8	24	1	24	1.44
	12	24	1	24	1.44
	16	25	1	25	1.5
	20	24	1	24	1.44
	25	23	1	23	1.38
	30	23	1	23	1.38
4	1	23	1	23	1.38
	4	23	1	23	1.38
	8	23	1	23	1.38
	12	22	1	22	1.32
	16	22	1	22	1.32
	20	21	1	21	1.26
	25	21	1	21	1.26
	30	20.5	1	20.5	1.23

Table 4-10A: The measured flow rate of emitter type (GR).

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	45	1	45	2.7
	5	50	1	50	3
	9	50	1	50	3
	13	45	1	45	2.7
	16	50	1	50	3
	19	45	1	45	2.7
	22	40	1	40	2.4
	25	40	1	40	2.4
2	1	50	1	50	3
	5	50	1	50	3
	9	45	1	45	2.7
	13	50	1	50	3
	16	45	1	45	2.7
	19	45	1	45	2.7
	22	45	1	45	2.7
	25	41.7	1	41.7	2.5

Table 4-10B: The measured flow rate of emitter type (GR).

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
3	1	50	1	50	3
	5	50	1	50	3
	9	50	1	50	3
	13	45	1	45	2.7
	16	45	1	45	2.7
	19	41.7	1	41.7	2.5
	22	45	1	45	2.7
	25	41.7	1	41.7	2.5
4	1	50	1	50	3
	5	50	1	50	3
	9	50	1	50	3
	13	40	1	40	2.4
	16	40	1	40	2.4
	19	40	1	40	2.4
	22	40	1	40	2.4
	25	40.0	1	40.0	2.4

4.4 Measuring the salinity of the water used for drip irrigation.

The sample was taken from the well's water used for growing crops, which were irrigated using a drip irrigation system to measure the amount of total dissolved solids in the water .The samples were brought to the sanitary laboratory at the College of Engineering at University of Karbala, and the result of total dissolved solids, (TDS) was about 7660 (mg/L). It was concluded that the amount of dissolved salts materials of very high value, and these salts led to a defect in the proper functioning of the drip irrigation system through its impact on the uniformity of distribution, emission uniformity, and clogging of the drippers.

CHAPTER FIVE
RESULTS AND DISCUSSION

5.1 Introduction

Drip irrigation evaluation in the field under operating conditions is very important to ensure that the desired emitter discharge uniformity and the hydraulic performance required for the system design is met and to see whether the system could be operated efficiently(Al-Ghobari, 2007).

5.2 Soil Physical Properties

Tests were carried out on soil samples irrigated by drip irrigation showed that the soil is sandy according to Table (4.7), this, in turn, determines the selection of the appropriate dripper, taking into account the plant's need for water and the type of plant. Sandy soil enables plants to a fast absorption of water by the free flow of water within its soil formation as stated by(Ankidawa and Zakariah, 2018a). (Keller and Bliesner, 1990) mentioned that sandy soils are suitable for the drip irrigation system, the values of the average bulk density rate are (1.656gm/cm^3), and the average specific gravity is (2.663).

5.3 System Performance Parameters

5.3.1 Efficiency of Application (E_a)

Tables (5.1 and 5.2) show the efficiency of application for 9 lateral lines for three different resources and two types of drippers mostly used locally. It was calculated using equation 3.1. Results are ranged from 73.4% to 86.8% when using dripper number one, and ranged from 82.5% to 94% when using dripper number two. Figure 5.1 shows a comparison of the four basic parameters for the three products used in this study under pressure (0.6,0.8 and1bar) and type of emitter1. While figure (5.6) shows a comparison for the same parameters and products under pressure (0.5,1 and 1.5bar).

Table (5.3) shows the efficiency of the application of drip irrigation of an existed farm, which is the agricultural development of the Administration of the Imam Hussein Shrine. It was calculated using equation (3.1), the results are ranged from (93%-96%) and the average was (94.5%) for pipe type (T-Tape), while they are ranged from (88%-91%) and the average was (89.75%) for pipe type (GR).

5.3.2 Field Emission Uniformity (EU_f):

Table (5.1) shows the uniformity of field emission of the drip irrigation system for nine lateral lines for three different resources and two types of emitters mostly used locally. The uniformity of distribution was calculated using equation (3.2) that mentioned in chapter three. The results are ranged from (73.4% to 88%) when using dripper number one, and ranged from (84% to 95%) when using dripper number two.

Table (5.3) shows the uniformity of field emission of the drip irrigation of a real farm, which is the agricultural development of the administration of the Imam Hussein shrine. It was calculated using equation (3.1), the results ranged from (94%-96%) with an average (95%) for pipe type(T-tape), and they ranged from (88-94%) with an average of (91.5%) for pipe type (GR).

5.3.3 Absolute Emission Uniformity (EU_a):

Tables (5.1 and 5.2) show the uniformity of Absolute emission of the drip irrigation system for nine latera lines for three different resources and two types of emitters mostly used locally. It was calculated using equation (3.3) which mentioned in chapter three. It was found that its values range between (73% - 86%) when using dripper number one, and ranged from (83% to 94%) when using dripper number two.

Table (5.3) shows the uniformity of Absolute emission of the drip irrigation of an existing farm, which is the agricultural development of the administration of the Imam Hussein shrine. It was calculated using equation 3.1, the results ranged from (94.9%-95.9%) with an average of (95.5%) for pipe type (T-Tape), and ranged from (89.4-94.5%) with an average of (92.4%) for pipe type (GR).

5.3.4 Uniformity of Design Emission EU_d :

Tables (5.1and 5.2) show the design emission uniformity of the drip irrigation system for the nine laterals lines for three different resources and two types of emitters mostly used locally. It was calculated using equation (3.4) mentioned in chapter three. The results showed that their values range between (70.8% - 85.2%) when using emitter, No 1, and ranged from (79.7% to 93%) when using emitter No2.

Table (5.3) shows the design emission uniformity of the drip irrigation of existing farm, which is the agricultural development of the administration of the Imam Hussein shrine. It was calculated using equation 3.1. The results ranged from (93%-95.5%) and average (94.4%) for pipe type (T-Tape), and ranged from (87%-90.6%) and average (92.4%) for pipe type (GR). Figures (5.1 and 5.6) show a relationship between hydraulic parameters and percentage in different pressures, the percentage for hydraulic parameters increased with increasing pressure.

Table 5-1: parameters of performance to assess drip irrigation system for all laterals lines with the emitter type one.

Type of Lateral	No. of lateral	Operating pressure(bar)	E_a, %	EU_f , %	EU_a, %	EU_d %	Evaluation
Local 1	1	0.6	73.5	74.8	73.2	70.8	Acceptable
		0.8	76.6	79.7	78.6	74.7	Acceptable
		1	79.1	80.6	78.2	77	Acceptable
	2	0.6	73.8	75	74.1	71.4	Acceptable
		0.8	76	80	78.8	73.9	Acceptable
		1	79	81.9	80.3	77.2	Acceptable
Local 2	1	0.6	73.4	76.8	75	71.2	Acceptable
		0.8	76.6	79.7	79	74.6	Acceptable
		1	81.2	82.6	80	79.2	Acceptable-Good
	2	0.6	74.7	77.6	74	72.3	Acceptable
		0.8	77	80.2	78.5	75	Acceptable
		1	80	82.7	80	78.1	Acceptable
Imported	1	0.6	79	81.4	80.5	77.2	Acceptable-Good
		0.8	83.8	85.4	82.4	82	Good
		1	86.2	87.9	86	84.8	Good
	2	0.6	79	80.6	79.7	77	Acceptable-Good
		0.8	82.2	83.7	81.4	80.4	Good
		1	86.8	88.1	84.8	85.2	Good

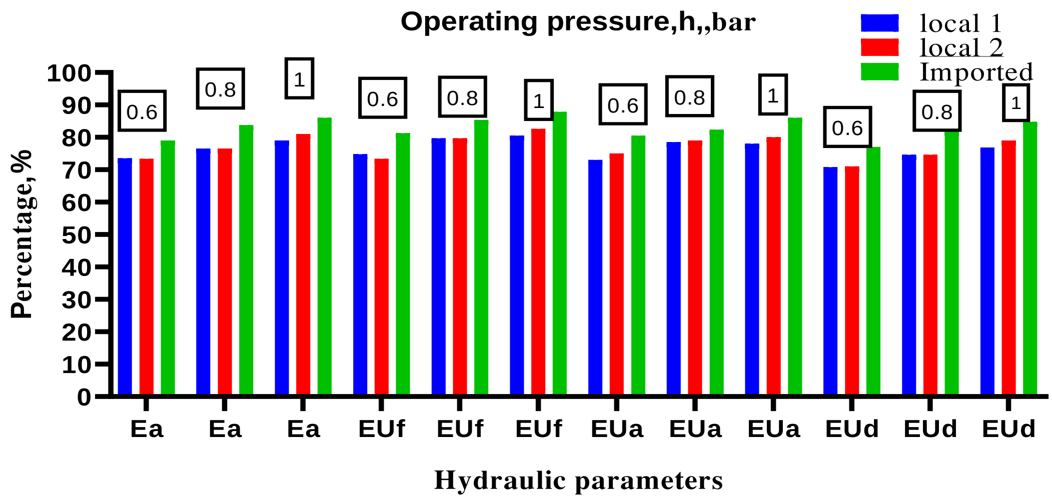

Figure 5.1 comparison of the four basic parameters (Ea, EU_F, EUa, and EUd), emitter type one.

The graphics in Figures (5.2,5.3,5.4 and 5.5) show the behavior of the parameters (E_a, EU_d, EU_F, and EU_a) for the three products, respectively for pressures (0.6,0.8 and 1bar) and emitter type one. While the graphics in Figures (5.7,5.8,5.9 and 5.10) show the behavior of the parameters (E_a, EU_d, EU_F, and EU_a) for the three products, respectively for pressures (0.5,1 and 1.5 bar) and emitter type two. Observed through these figures that the hydraulic parameters of the imported product are higher than the hydraulic parameters of the local products, with the presence of convergence between the hydraulic parameters of the local products, also and the hydraulic parameters are increased with increasing of operating pressure in local and imported products. The increase in pressure leads to a decrease in the relative differences in discharge between the beginning and end of the lateral lines, and as a result, the coefficients of the different parameters increase.

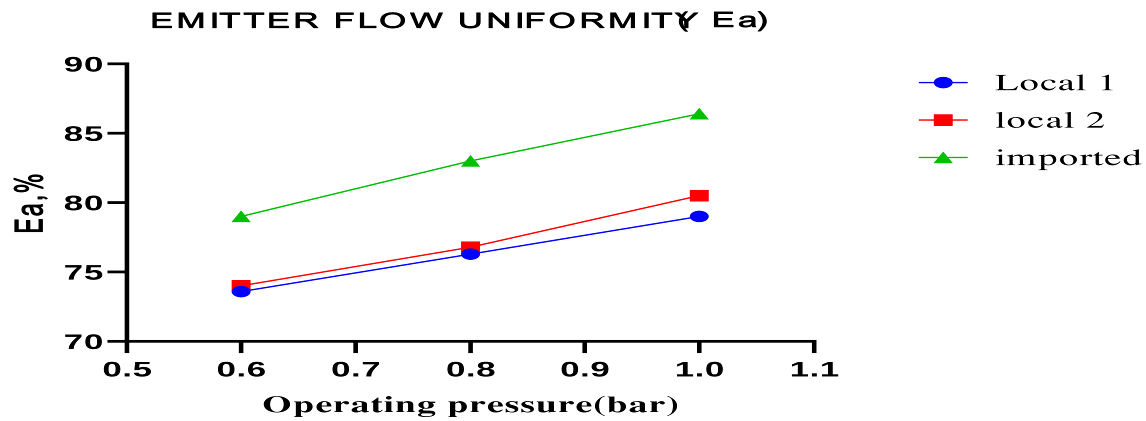

Figure 5.2 The behavior of the parameters (E_a) for the three products and emitter type one.

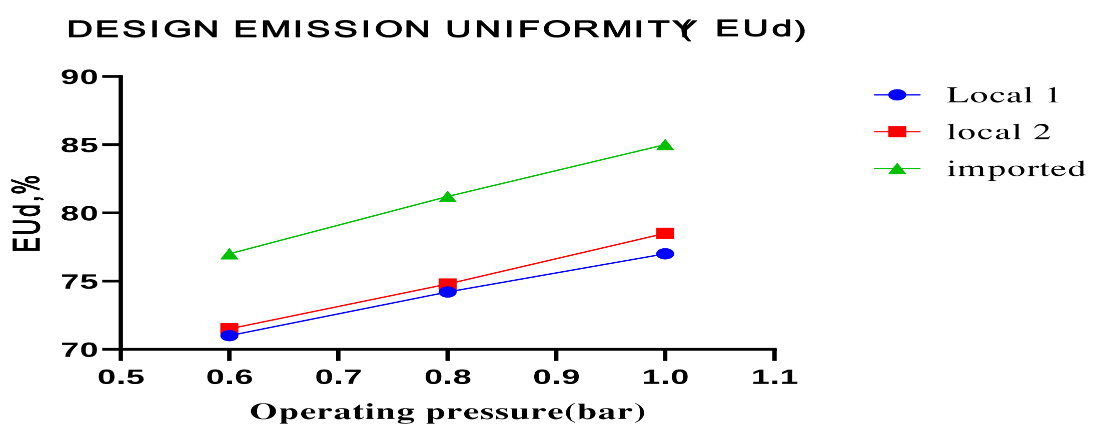

Figure 5.3 The behavior of the parameters (EU_d) for the three products and emitter type one.

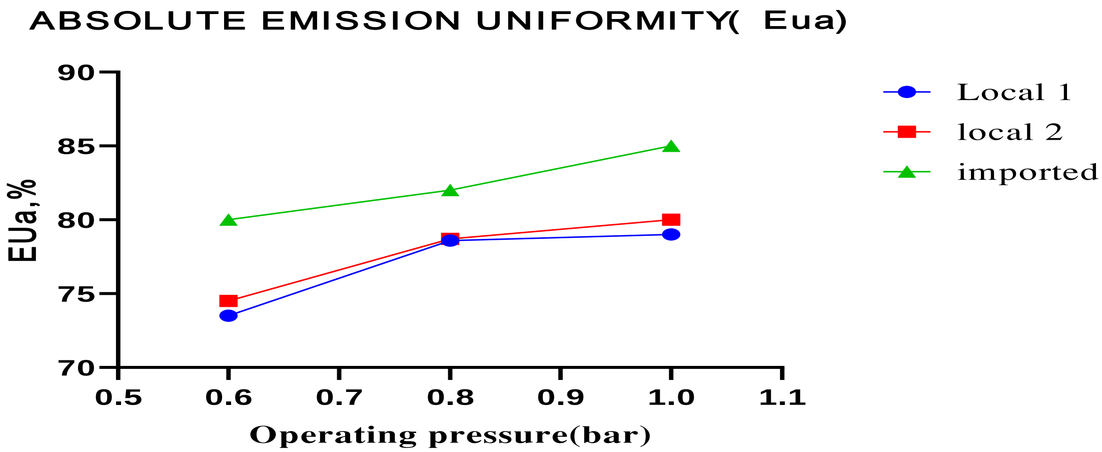

Figure 5.4 The behavior of the parameters (EU_a) for the three products and emitter type one.

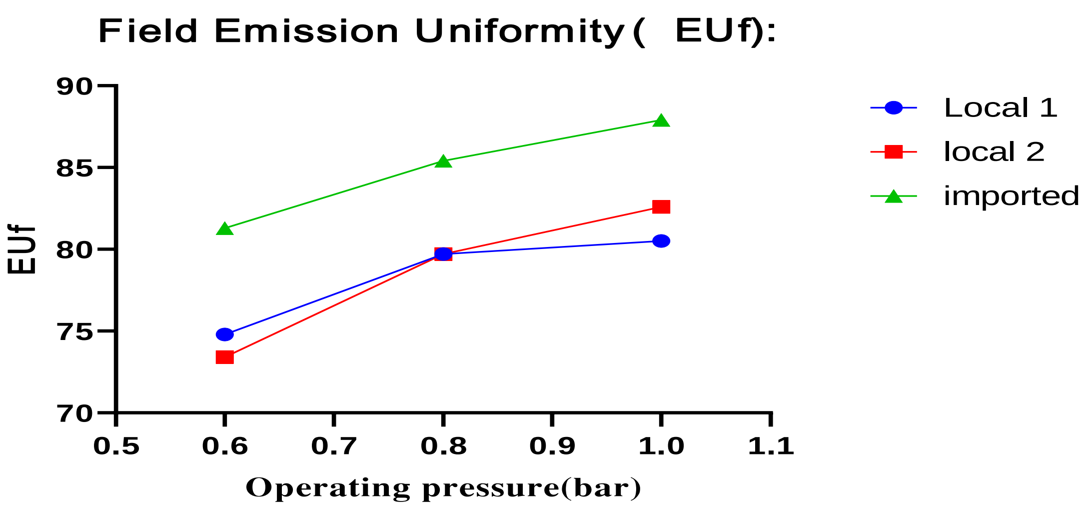

Figure 5.5 The behavior of the parameters (EU_F) for the three products and emitter type one.

Table 5-2: parameters of performance to assess drip irrigation system for the laterals lines with emitter type two.

Type. Lateral	pressure(bar)	E_a, %	EU_f, %	EU_a, %	EU_d, %	Evaluation
Local (1)	0.5	82.5	84	83.8	79.7	Acceptable-Good
	1	85.6	87.6	84.6	83	Good
	1.5	89.2	91	88.6	87.2	Good- Excellent
Local (2)	0.5	83.3	84.7	83.3	80.3	Good
	1	87	88.6	88.4	84.9	Good
	1.5	90.6	92	90	88.8	Good -Excellent
imported	0.5	88.6	89.2	87.9	86.4	Good
	1	91.5	92.8	92.5	90.3	Excellent
	1.5	94.5	94.8	93.7	93.2	Excellent

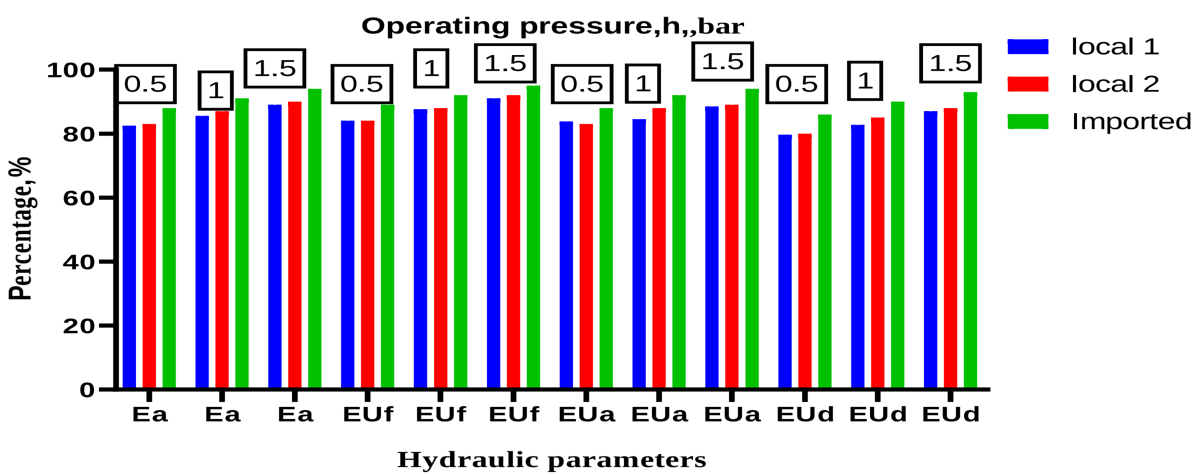

Figure 5.6 comparison of the four basic parameters (E_a, EU_F, EU_a, and EU_d) for the three products with emitter type two.

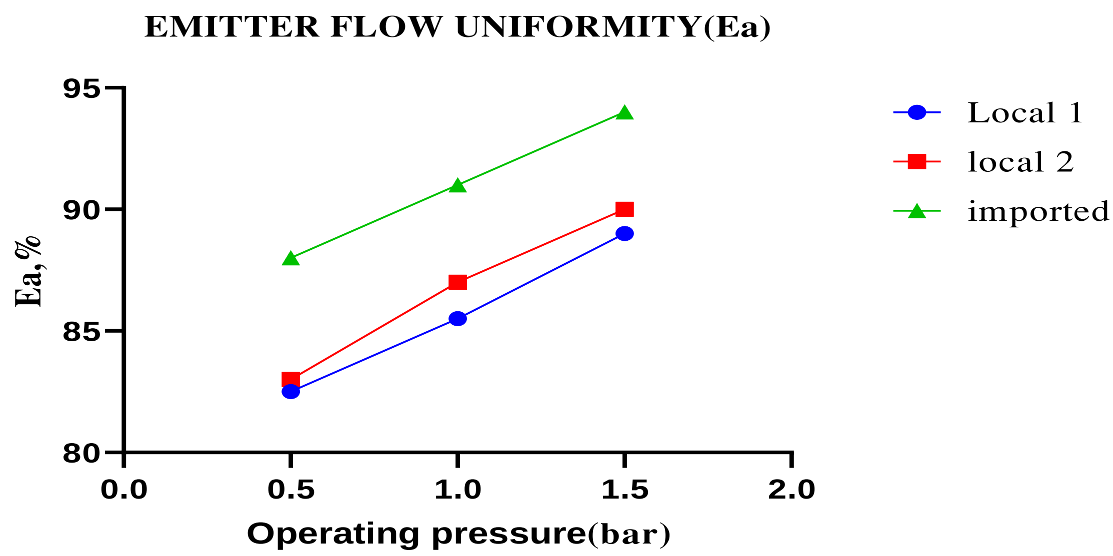

Figure 5.7 Diagram showing the behavior of the parameters (E_a) for the three products with emitter type two.

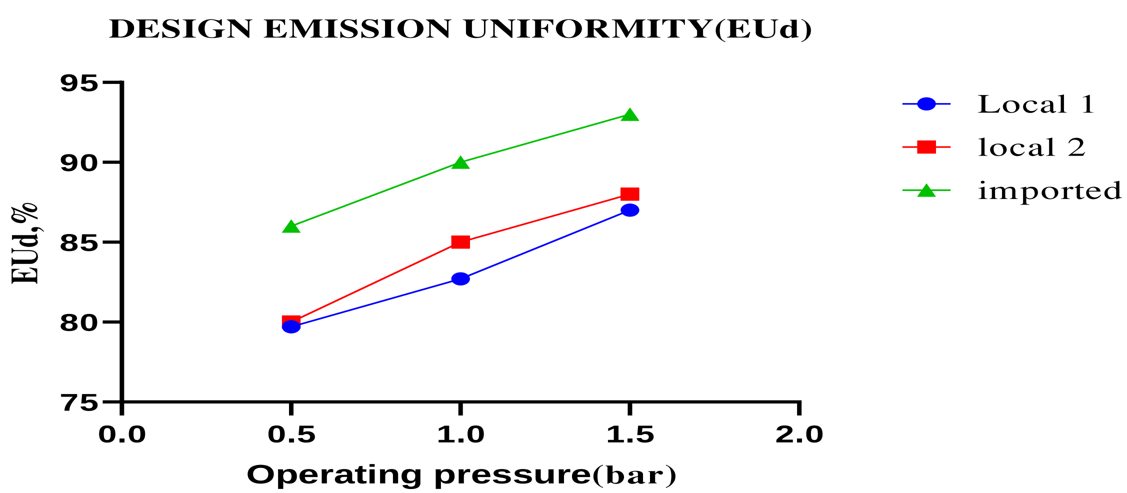

Figure 5.8 Diagram showing the behavior of the parameters (EU_d) for the three products with emitter type two.

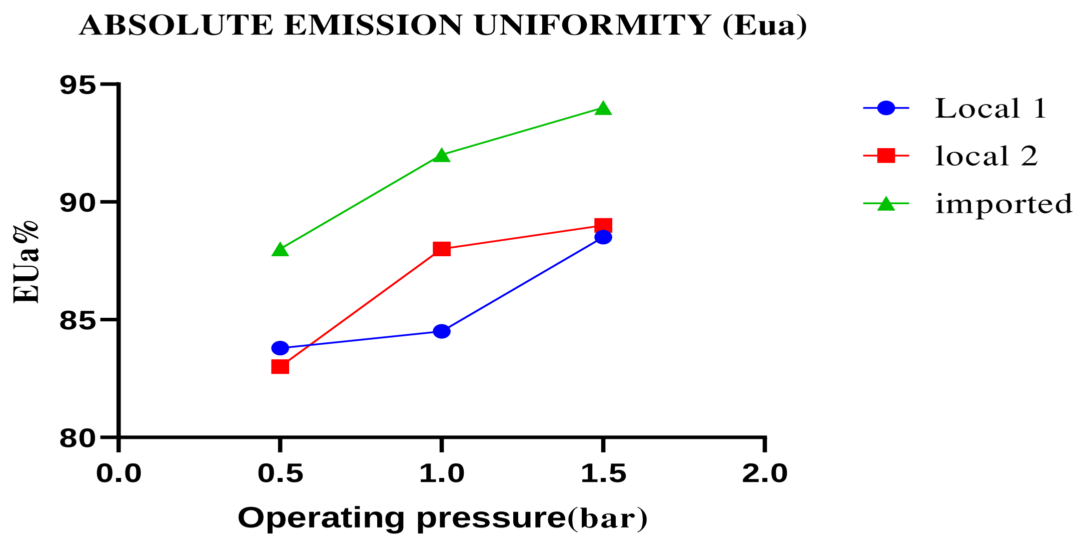

Figure 5.9 Diagram showing the behavior of the parameters (EU_a) for the three products with emitter type two.

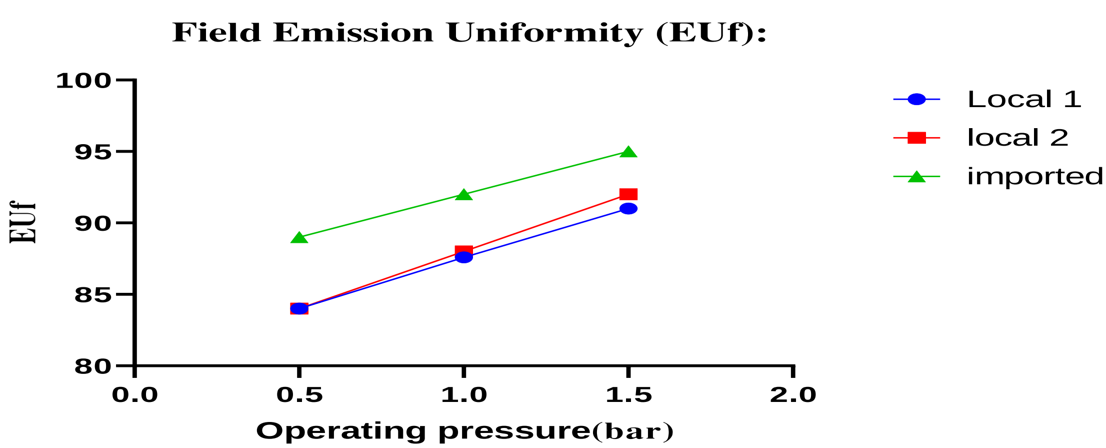

Figure 5.10 Diagram showing the behavior of the parameters (EU_F) for the three products with emitter type two.

Table 5-3 Performance parameters (E_a, EU_f, EU_a, and EU_d) for the lateral's lines in the agricultural development farm.

Type. Lateral	No. of lateral	E_a, %	EU_f, %	EU_a, %	EU_d, %	Evaluation
T-Tape	1	96	96	95.9	95.5	Excellent
	2	94	94	95.5	94	Excellent
	3	95	95	95.9	95	Excellent
	4	93	95	94.9	93	Excellent
	average	94.5	95	95.5	94.4	Excellent
GR	1	88	88	94.5	87	Good- Excellent
	2	90	93	93	89	Good- Excellent
	3	90	94	93	90	Excellent
	4	91	91	89.4	90.6	Excellent
	average	89.75	91.5	92.4	89	Good- Excellent

5.3.5 Statistical Uniformity Coefficient (SU_c) and Coefficient of Variation (c_v)

Tables (5.4 and 5.5) show the statistical uniformity coefficients of the drip irrigation system for nine lateral lines. It was calculated using equation (3.6) mentioned in chapter three. The values of the statistical uniformity factor **(**SU_c**)** for the irrigation system ranged between (74%-89%), it was classified as (fair to very good) according to what was mentioned by (EL-NEMR, 2012) for pressures (0.6,0.8 and 1bar) and type of emitter No 1. while the values ranged between (86%-95%), and classified as (very good to Excellent) for pressures (0.5,1 and 1.5bar) and type of emitter (2).The value of (c_v) for the irrigation system ranged between (0.26-0.11%) for pressures(0.6, 0.8 and 1 bar) and dripper number 1.It is classified as (Acceptable to very good) according to what was mentioned by(Solomon, 1979). While they ranged between (0.13-0.05%) for pressures (0.5, 1 and 1.5 bar) and dripper number 2, and it is classified as (very good to Excellent) according to what was mentioned by(Solomon, 1979).

Table 5-4: The Statistical uniformity coefficient and coefficient of variation with emitter type one.

Type. Lateral	No. of lateral	Pressure(bar)	SU_c, %	Evaluation	c_v	Evaluation
Local (1)	1	0.6	74	Fair	0.26	acceptable
		0.8	83	very good	0.17	very good
		1	81	very good	0.19	very good
	2	0.6	76	Fair	0.24	acceptable
		0.8	82	very good	0.18	very good
		1	83	very good	0.17	very good
Local (2)	1	0.6	78	Fair	0.22	acceptable
		0.8	82	very good	0.18	very good
		1	82	very good	0.18	very good
	2	0.6	77	Fair	0.23	acceptable
		0.8	82	very good	0.18	very good
		1	83	very good	0.17	very good
Imported	1	0.6	83	very good	0.17	very good
		0.8	84	very good	0.16	very good
		1	89	very good	0.11	very good
	2	0.6	83	very good	0.17	very good
		0.8	84	very good	0.16	very good
		1	87	very good	0.13	very good

Table 5- 5: The Statistical uniformity coefficient and coefficient of variation with emitter type two.

Type. Lateral	pressure (bar)	SU_c, %	Evaluation	c_v	Evaluation
Local (1)	0.5	86	very good	0.13	very good
	1	87	very good	0.12	very good
	1.5	91	Excellent	0.08	Excellent
Local (2)	0.5	85.5	very good	0.14	very good
	1	91	Excellent	0.09	Excellent
	1.5	92	Excellent	0.07	Excellent
Imported	0.5	90	very good	0.09	Excellent
	1	94	Excellent	0.05	Excellent
	1.5	95	Excellent	0.05	Excellent

Table 5- 6: The Statistical uniformity coefficient and coefficient of variation in agricultural development farm.

Type. Lateral	No. of lateral	SU_c, %	Evaluation	c_v	Evaluation
T-Tape	1	96	Excellent	0.04	Excellent
	2	96	Excellent	0.04	Excellent
	3	96	Excellent	0.03	Excellent
	4	95	Excellent	0.05	Excellent
	Average	96	Excellent	0.04	Excellent
GR	1	91	Excellent	0.09	Excellent
	2	93	Excellent	0.07	Excellent
	3	92	Excellent	0.08	Excellent
	4	88	very good	0.12	very good
	Average	91	Excellent	0.09	Excellent

5.3.6 Emitter Flow Rate Variation (q_{var}) and Pressure Variation

Tables (5.7 and 5.8) show the discharge variation at the lateral lines. It was calculated using equation (3.7) mentioned in chapter three. The variation in the lateral emitter flow rate was found to be over than the maximum variation in the discharge allowed by 10% as indicated by Michael (1978), as the values ranged between (48.7%-32.6%) on all lateral lines when using the dripper type one and the values ranged between (31%-12.5%) on all lateral lines when using the dripper type two.

Table 5-7: The discharge variation (q_{var}) for all lateral with emitter type one.

Type. Lateral	No. of lateral	pressure(bar)	q_{var}%	Evaluation
Local (1)	1	0.6	48.7	not acceptable
		0.8	42.9	not acceptable
		1	42.6	not acceptable
	2	0.6	48.7	not acceptable
		0.8	44	not acceptable
		1	40.4	not acceptable
Local (2)	1	0.6	50	not acceptable
		0.8	42.8	not acceptable
		1	39.6	not acceptable
	2	0.6	50	not acceptable
		0.8	44.2	not acceptable
		1	39.6	not acceptable
Imported	1	0.6	39.5	not acceptable
		0.8	34.9	not acceptable
		1	29.8	not acceptable
	2	0.6	39.5	not acceptable
		0.8	36.4	not acceptable
		1	32.6	not acceptable

Table 5-8: The discharge variation (q_{var}) for pressures (0.5,1 and 1.5 bar) with emitter type two.

Type. Lateral	Operating pressure(bar)	q_{var}%	Evaluation
Local (1)	0.5	31	not acceptable
	1	30.2	not acceptable
	1.5	23	acceptable
Local (2)	0.5	32	not acceptable
	1	23	acceptable
	1.5	20	acceptable
Imported	0.5	23	acceptable
	1	15.6	acceptable
	1.5	12.5	acceptable

Table 5-9: discharge variation (q_{var}) in agricultural development farm.

Type. Lateral	No. of lateral	q_{var}%	Evaluation
T-Tape	1	8	desirable
	2	8.7	desirable
	3	8	desirable
	4	10	acceptable
	Average	8.6	desirable
GR	1	20	acceptable
	2	16.7	acceptable
	3	16.7	acceptable
	4	20	acceptable
	Average	18.3	acceptable

Tables (5.10 and 5.11) show the pressure variation(h_{var}) at the head and end of the lateral lines. The pressure variation was calculated using equation 3.8 mentioned in chapter three. The maximum pressure variation allowed as stated by Michael (1978) is 20%. The value (h_{var}) ranged between (40%-44.9%) in all lateral lines when using the dripper one and the values ranged between (10.2%-25.1%) in all lateral lines when using the dripper two.

Table 5-10: Pressure variation (h_{var}) with emitter type one**.**

Type. Lateral	No. of lateral	Operating pressure(bar)	Position of Emitter		(h_{var}) %
			head	end	
Local (1)	1	0.6	6.12	3.47	43.3
		0.8	7.96	4.49	43.6
		1	9.69	5.81	40
	2	0.6	6.12	3.47	43.3
		0.8	7.96	4.49	43
		1	9.69	5.81	40
Local (2)	1	0.6	6.12	3.57	41.7
		0.8	8.16	4.49	45
		1	9.69	5.41	44.2
	2	0.6	6.12	3.57	41.7
		0.8	7.96	4.49	43.6
		1	9.79	5.51	43.7
Imported	1	0.6	6.12	3.37	44.9
		0.8	7.96	4.49	43.6
		1	9.69	5.61	42.1
	2	0.6	6.12	3.37	44.9
		0.8	7.96	4.49	43.6
		1	9.59	5.61	41.5

Table 5-11: Pressure variation (h_{var}) with emitter type two.

Type. Lateral	Operating pressure(bar)	Position of Emitter (m)		(h_{var}) %
		head	end	
Local (1)	0.5	4.9	3.67	25.1
	1	10	8.77	12.3
	1.5	14.99	13.26	11.5
Local (2)	0.5	5.10	3.88	23.9
	1	10	8.67	13.3
	1.5	14.99	13.26	11.5
Imported	0.5	5	4.08	18.4
	1	10	8.8	12
	1.5	14.99	13.46	10.2

The Figures (5.11,5.12,5.13,5.14,5.15, and 5.16) and through Tables (C1.1, C1.2, C1.3, C2.1, C2.2, C2.3, C3.1, C3.2, C3.3, C4, and C5) in appendix C and Table 4.11 in chapter four, noted that with the decrease in pressure, the discharge decreases from emitters in each of the imported laterals lines and locally laterals lines with a significant increase in the values of the local product on the values of the local results.

Through the results obtained from the experiments conducted in the agricultural development farm, they were very close to the previous study by(Abdulhadi and Alwan, 2020) Which was conducted in the same governorate at Fadak Farm and the emitters were a pressure compensator and the same origin for the laterals lines. While there was a significant difference in the results of the value of the drip irrigation network that was established, due to the quality of the emitter used, which non-compensated emitters for pressure and of a primitive and simple quality.

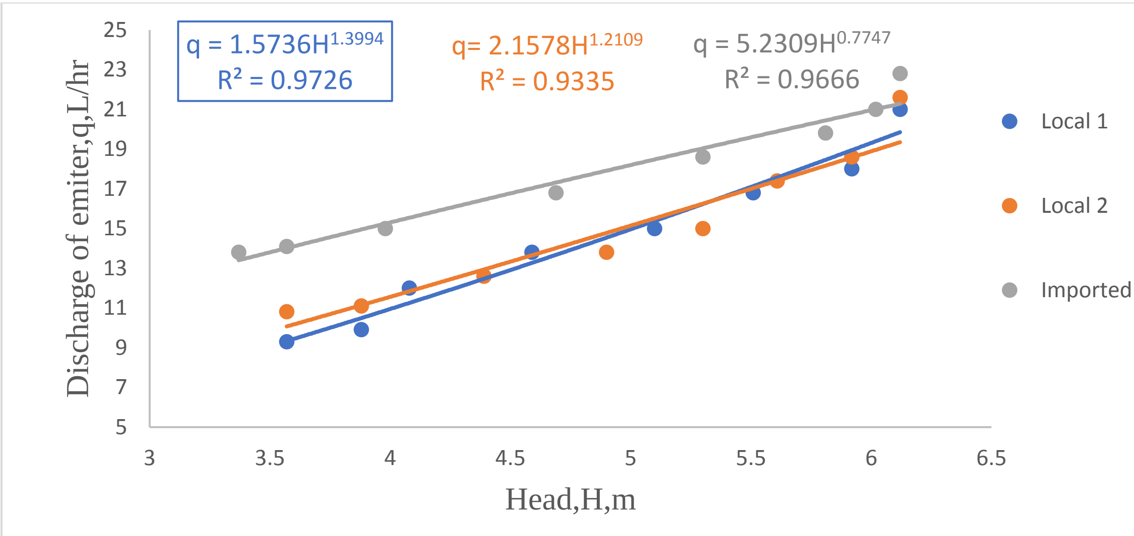

Figure 5.11 Relationship between pressure change with discharge in each measured emitter, pressure (0.6 bar) with emitter type one and lateral one.

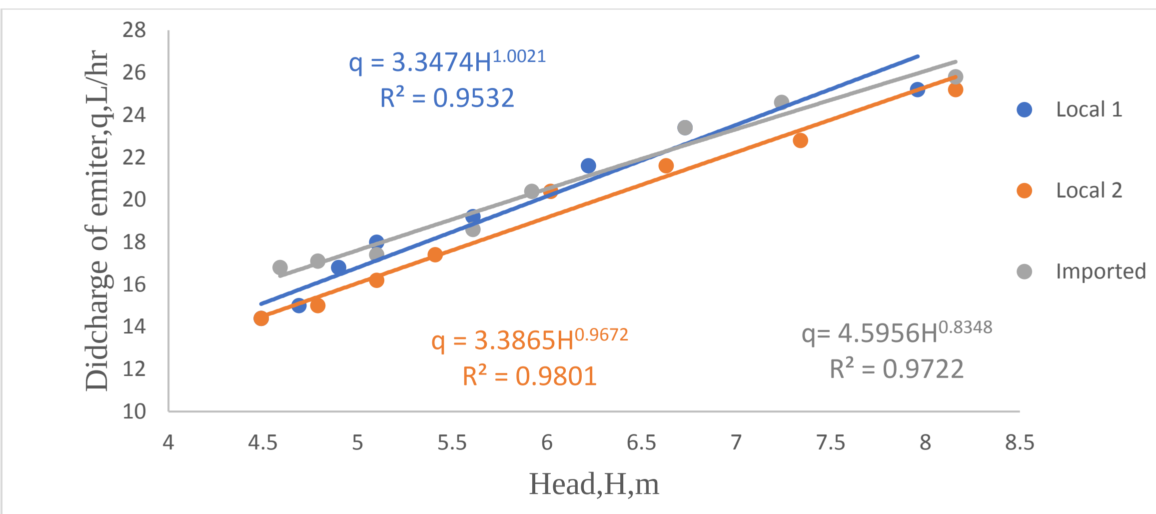

Figure 5.12 Relationship between pressure change with discharge in each measured emitter, pressure (0.8 bar), with emitter type one and lateral one.

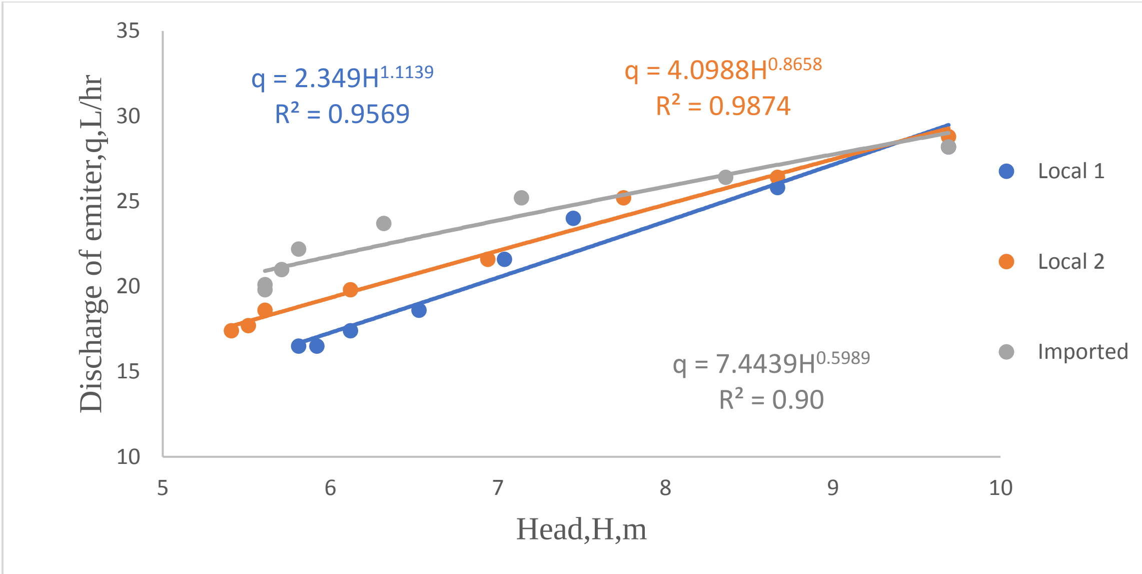

Figure 5.13 Relationship between pressure change with discharge in each measured emitter, pressure (1 bar) with emitter type one and lateral one.

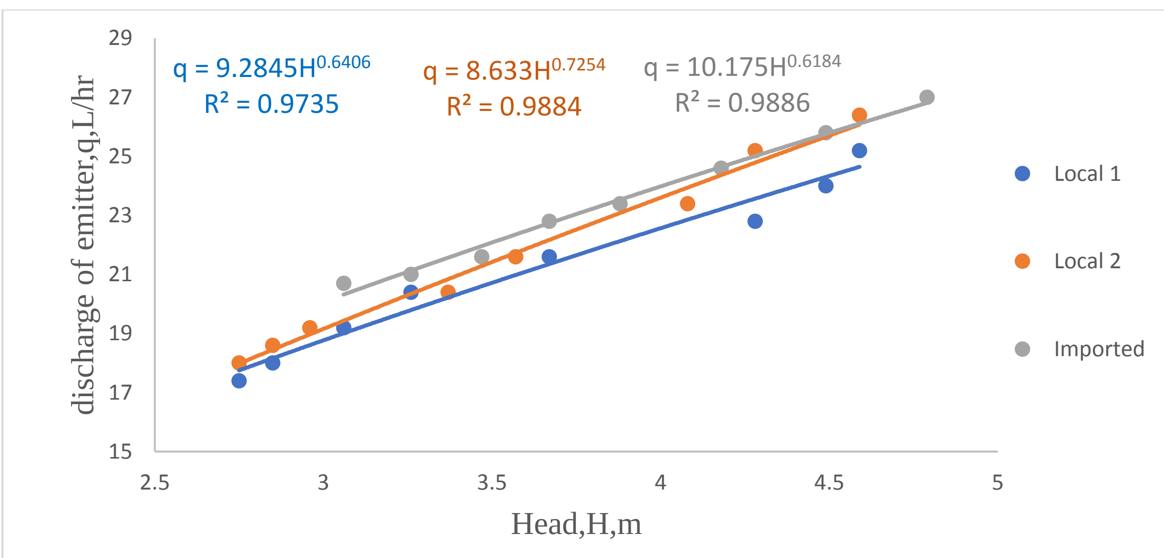

Figure 5.14 Relationship between pressure change with discharge in each measured emitter, pressure (0.5 bar) with emitter type two and lateral one.

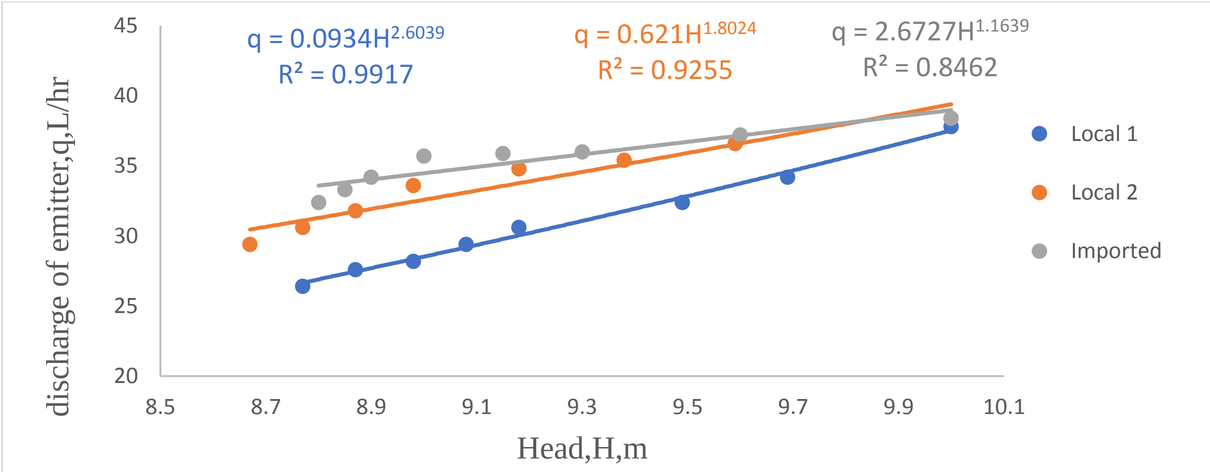

Figure 5.15 Relationship between pressure change with discharge in each measured emitter for the three products, pressure(1bar) with emitter type two and lateral one.

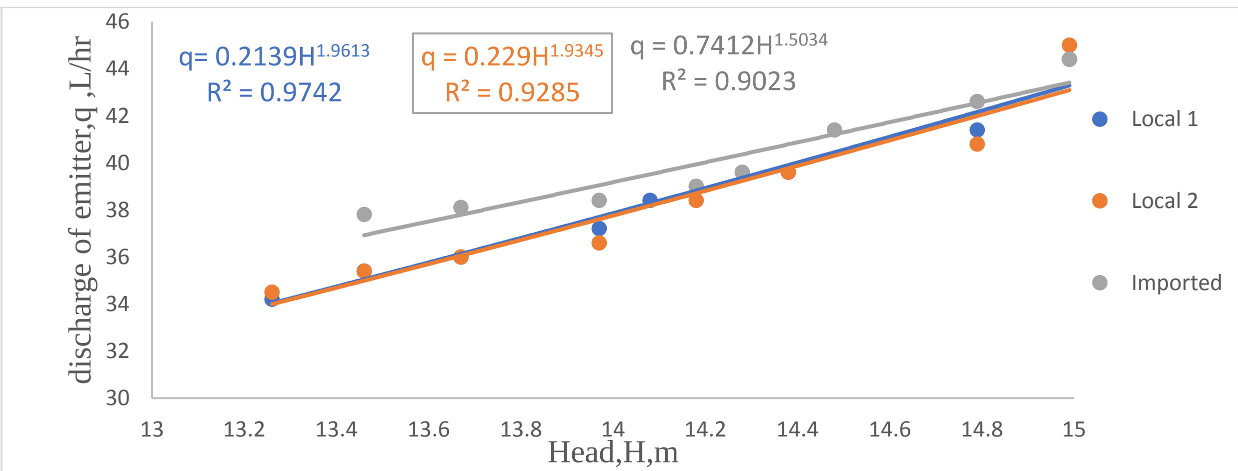

Figure 5.16 Relationship between pressure change with discharge in each measured emitter, pressure (1.5bar) with emitter type two and lateral one.

5.4 Hydraulics evaluation of trickle irrigation lines

Table 5.12 shows the values of head losses due to friction of the drip irrigation system for the 9 lateral lines for three different resources and two emitters types most used locally. It was calculated using equation (3.14) mentioned in chapter three, correction factor was calculated using equation (3.16). The results showed that their values range between (0.46 -1.4) where the lateral length is 25 m, the number of drippers is 25 and the diameter of the lateral line pipe 16 mm, and the roughness coefficient C = 140 for produced local and c=150 for produced imported.

From Tables (5.12,5.13)., it is noted that the values of losses due to friction of the used pipes are close for all imported and the local ones. Figures (5.17,5.18, and 5.19) show the pressure-distance relationship calculated from Hazen-William equation with the pressure values obtained from the field while calculating the pressure in drippers number one, in addition, Figures (5.20,5.21, and 5.22) show the pressure-distance relationship calculated from Hazen-William equation with the pressure values obtained from the field while calculating the pressure in drippers number two , the pipe roughness coefficient (C) has been used(C=140) for products local and C=150 for products imported because this value gives the least error between the values calculated by the equation and the values of the field by calculating the losses by the Hazen-William equation and comparing the calculated head results with the head obtained from the experiment.

Table 5-12 The head loss due to friction of the drip irrigation system, emitter No1.

Type. Lateral	Operating pressure(bar)	Total head loss due to friction H_f (m)
Local 1	0.6	1.65
	0.8	2.25
	1	2.63
Local 2	0.6	1.43
	0.8	2.25
	1	2.86
Imported	0.6	1.96
	0.8	2.53
	1	3.26

Table 5-13 The head loss due to friction of the drip irrigation system emitter No2.

Type. Lateral	Operating pressure(bar)	Total head loss due to friction H_f (m)
Local 1	0.5	0.46
	1	0.93
	1.5	1.4
Local 2	0.5	0.48
	1	1.11
	1.5	1.38
Imported	0.5	0.49
	1	1.06
	1.5	1.34

5.5TheStatistical Error Indices: Statistical error indicators have been calculated for all lateral's lines used in this study for (agricultural development) farm, Table (5.20) show data of measurement for (RMSE, MAPE and MBE) using equations (3.22,3.23 and 3.24) in chapter three.

Through the pressures at the emitters that were measured by experiment in farm and calculated pressures by applying the Hazen-William equation 3.13 and extracting the losses at each emitter and knowing the operating pressure of 1 bar, the pressures at each emitter were extracted and by applying the numbered equations (3.22,3.23 and 3.24), the results are shown in Tables (5.14 to 5.18) that the lowest value of the three coefficients (RMSE, MAPE, and MBE) is for emitter type one at roughness coefficient of pipes equal to140 for local products, therefore, conclude that the value of C was using about 140 to pipes local product. On the other hand, the most scientific sources mention that the recommended value of C of the plastic pipes is 150.

Table 5.14 Error of statistical index between pressure data from the field and computed for lateral's lines, emitter one at pressure 1 bar, C=120.

Pressure, m(C=120)			
Error Index	RMSE (L/h)	MAPE (%)	MBE(L/h)
Local one	0.263	1.026	0.06
Local two	0.28	1.249	0.075
Imported	0.429	1.86	0.1

Table 5.15 Error of statistical index between pressure data from the field and computed for lateral's lines, emitter one at pressure 1 bar, C=130.

Pressure, m(C=130)			
Error Index	RMSE (L/h)	MAPE (%)	MBE (L/h)
Local one	0.105	0.289	0.015
Local two	0.107	0.41	0.024
Imported	0.2269	0.888	0.049

Table 5.16 Error of statistical index between pressure data from the field and computed for lateral's lines, emitter one at pressure 1 bar, C=140.

Pressure, m(C=140)			
Error Index	RMSE (L/h)	MAPE (%)	MBE L/h)
Local one	0.079	0.29	0.021
Local two	0.07	0.26	0.016
Imported	0.22	0.888	0.049

Table 5.17 Error of statistical index between pressure data from the field and computed for lateral's lines, emitter one at pressure 1 bar, C=150.

Pressure, m(C=150)			
Error Index	RMSE (L/h)	MAPE (%)	MBE L/h)
Local one	0.17	0.77	0.05
Local two	0.18	0.814	0.04
Imported	0.12	0.50	0.035

Table 5.18 Error of statistical index between pressure data from the field and computed for lateral's lines, emitter one at pressure 1 bar, C=160.

Pressure, m(C=160)			
Error Index	RMSE (L/h)	MAPE (%)	MBE L/h)
Local one	0.26	1.17	0.077
Local two	0.27	1.26	0.07
Imported	0.22	1.05	0.06

Table 5.19 Error of statistical index between pressure data from the field and computed for lateral's lines, emitter two at pressure 1 bar.

Pressure, m(C=140)			
Error Index	RMSE(L/h)	MAPE (%)	MBE L/h)
Local one	0.11	0.67	0.06
Local two	0.059	0.25	0.022
Pressure, m(C=150)			
Error Index	RMSE(L/h)	MAPE (%)	MBE L/h)
Imported	0.049	0.26	0.024

Table 5.20 Error of statistical index for data of measurement for (agricultural development), type T-Tape.

Discharge (L/h)			
Error Index	RMSE (L/h)	MAPE (%)	MBE L/h)
Lateral Line 1	0.08	3.2	0.06
Lateral Line2	0.17	12.5	0.165
Lateral Line3	0.07	3.7	0.052
Lateral Line4	0.19	14.17	0.18

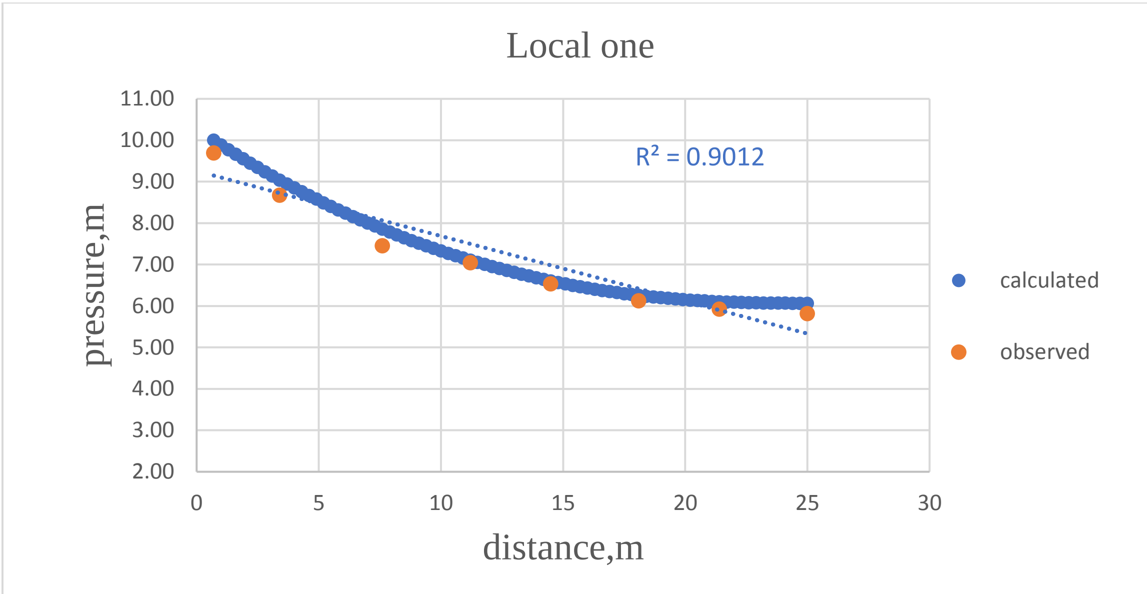

Figure 5.17 Relationship between pressure measured at the field and between calculated from Hazen-William equation for emitter type one for local one.

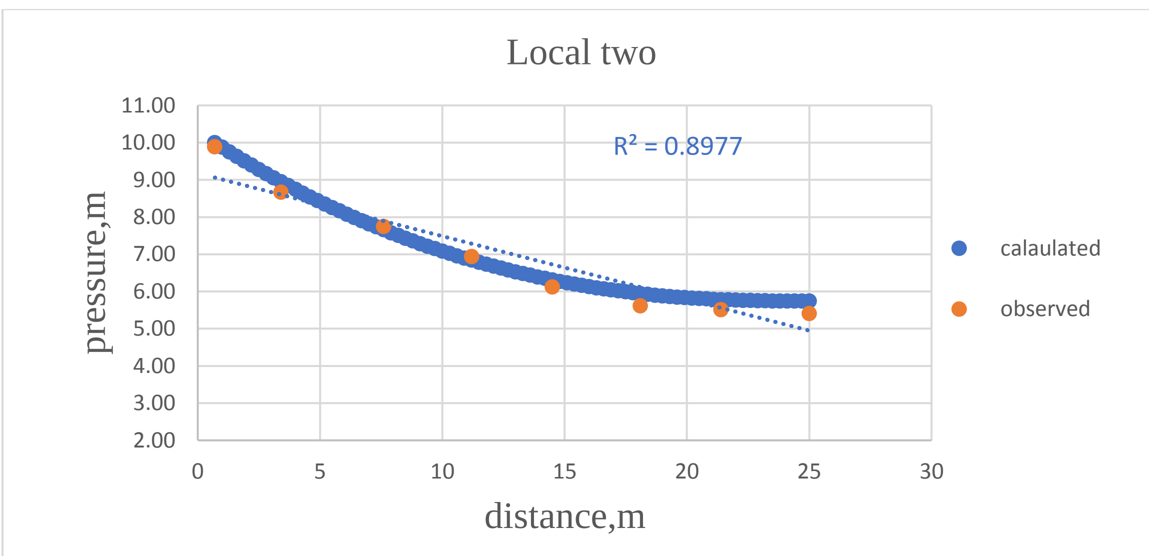

Figure 5.18 Relationship between pressure measured at the field and between calculated from Hazen-William equation for emitter type one for local two.

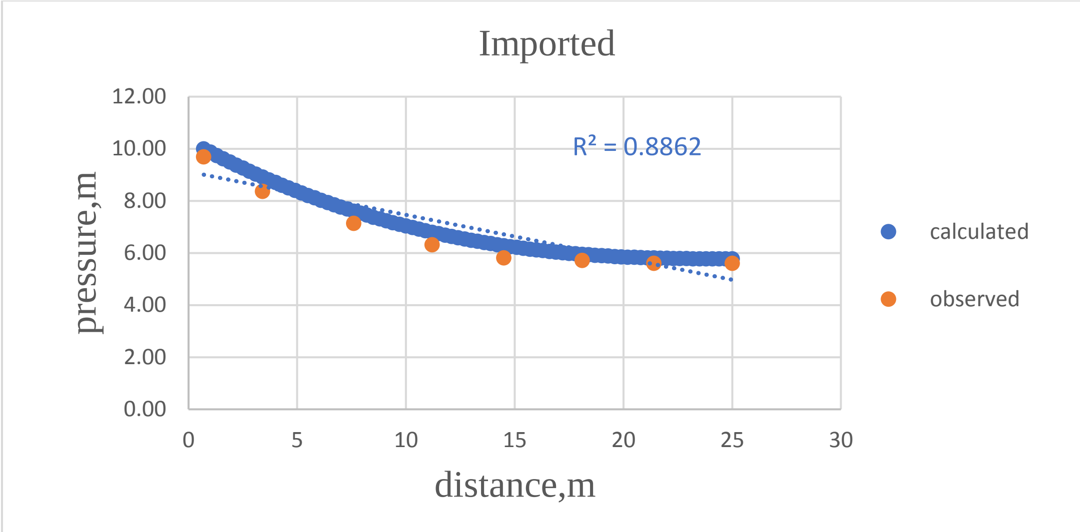

Figure 5.19 Relationship between pressure measured at the field and between calculated from Hazen-William equation for emitter type one for imported.

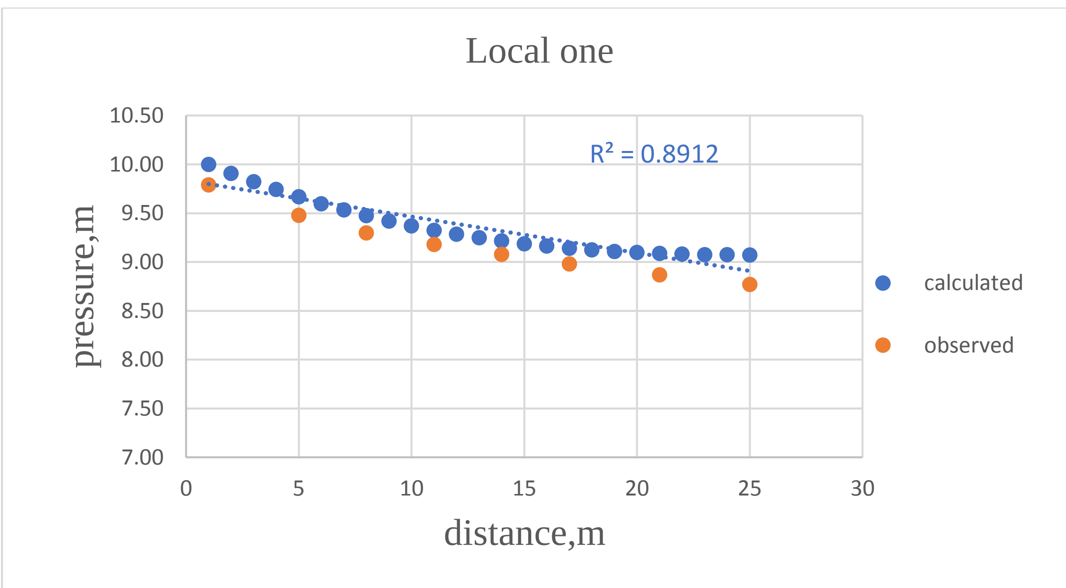

Figure 5.20 Imported Relationship between pressure measured at the field and between calculated from Hazen-William equation for emitter type two for local one.

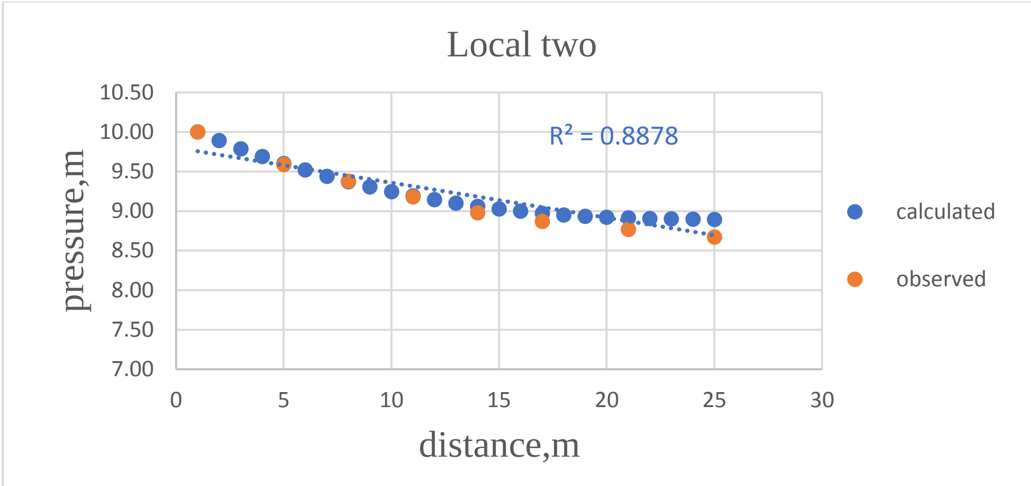

Figure 5.21 Imported Relationship between pressure measured at the field and between calculated from Hazen-William equation for emitter type two for local two.

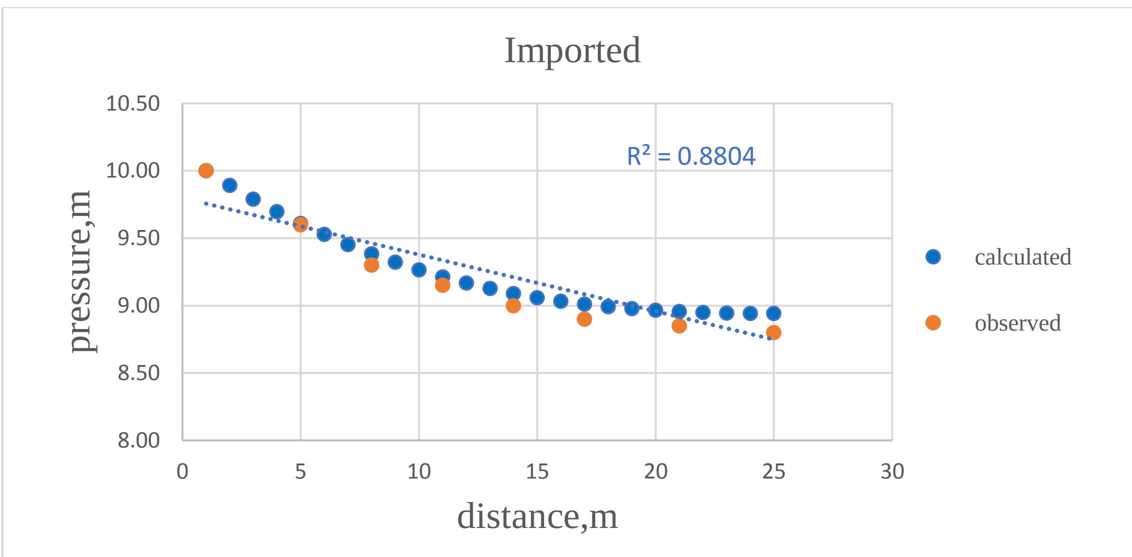

Figure 5.22 Imported Relationship between pressure measured at the field and between calculated from Hazen-William equation for emitter type two for imported.

Figures (5.23 to 5.26) show a Scheme of measured discharge from emitters in lateral lines for the study area part in the agricultural development farm, produced by the Jordanian company (Universal) for type (T-Tape) system, used in the farm. The manufacturer of the emitters indicates that the emitters work a discharge of 1.5 liters per hour, which means that there was a deviation in emitters work. This is due to the clogging of the emitters resulting from the accumulation of salts, sand, and impurities, the lack of periodic maintenance and continuous cleaning of the network.

Figure 5.23 Variation of measured discharge of emitters with its location in the lateral line No1 of agricultural development farm.

Figure 5.24 Variation of measured discharge of emitters with its location in the lateral line No2 of agricultural development farm.

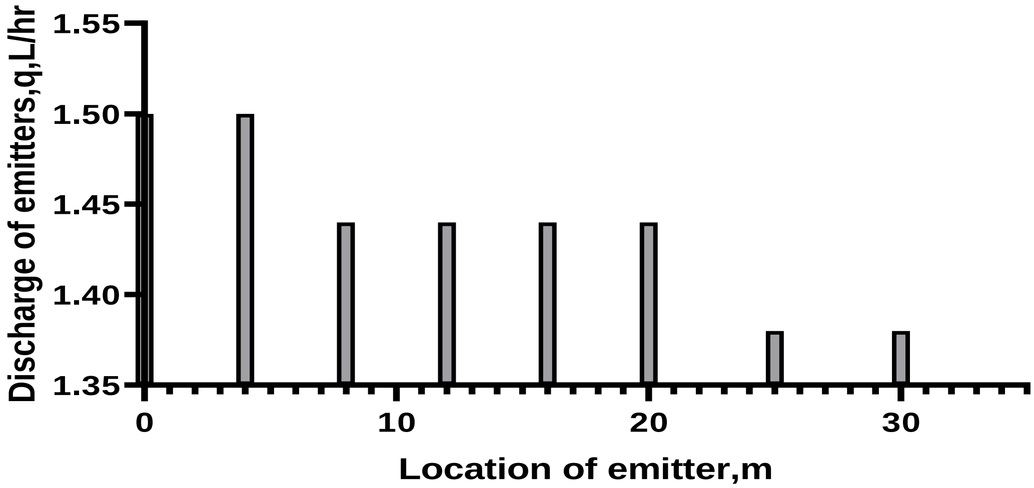

Figure 5.25 Variation of measured discharge of emitters with its location in the lateral line No3 of agricultural development farm.

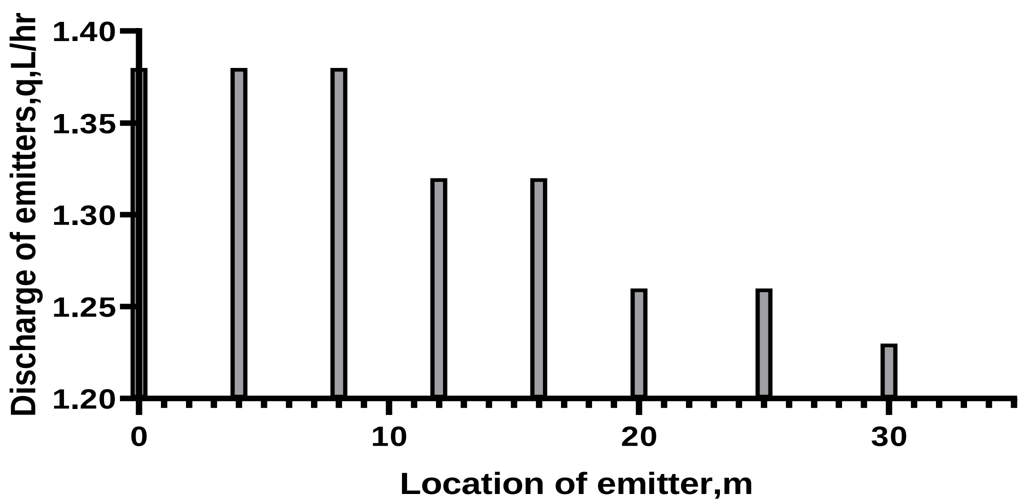

Figure 5.26 Variation of measured discharge of emitters with its location in the lateral line No4 of agricultural development farm.

5.6 Software program

5.6.1 Irricad Program

A part of the agricultural development farm affiliated to the administration of the Husseiniya holy shrine was re-designed, the part that works with the T -TAPE system, and the design results were compared with the results of the reality of the situation**.** Irricad Program is characterized by ease of use and accurate results, and it is one of the specialized programs for the design of drip irrigation systems. Table 5.20 shows a comparison between the results obtained from the program with those used in the field.

Figure 5.27 shows a layout diagram of main, semi-main pipes, and laterals lines in the study area and everything related to the dimensions of the lateral lines and their distribution. Figure 5.28 shows a report on the results of the design of the mainline of the pipe such as flow and pressure in multiple clips. Figure 5.29 shows report on the all water requirements of plants in the design area, Figure 5.30 shows a report for system duty of design (pressure and flow). Figure 5.31 lists the bill of materials necessary in the design. Figure 5.32 shows hydraulic grade line for Sub main. Figure 5.33 shows valve pressure and required pressure for zones operating. Figure 5.34 summarizes zone control valve for the study area. Figure 5.35 shows a report of zone design allowable and actual for flow and pressure. Figure 5.36 shows a report of zone pipes design for the study area.

Table 5.21 Comparison between designed and program results.

Materials	from the program	field user
Mainline	3″ (75mm)	4″(101.6mm)
Subline	2″ (50mm)	3″ (76.2mm)
Gate valve	1.1/2″	2.1/2″

By comparing the pipe sizes used in the field and what was obtained from the program in Table 5.21, it is noticed that the program values are less than those used in the farm.

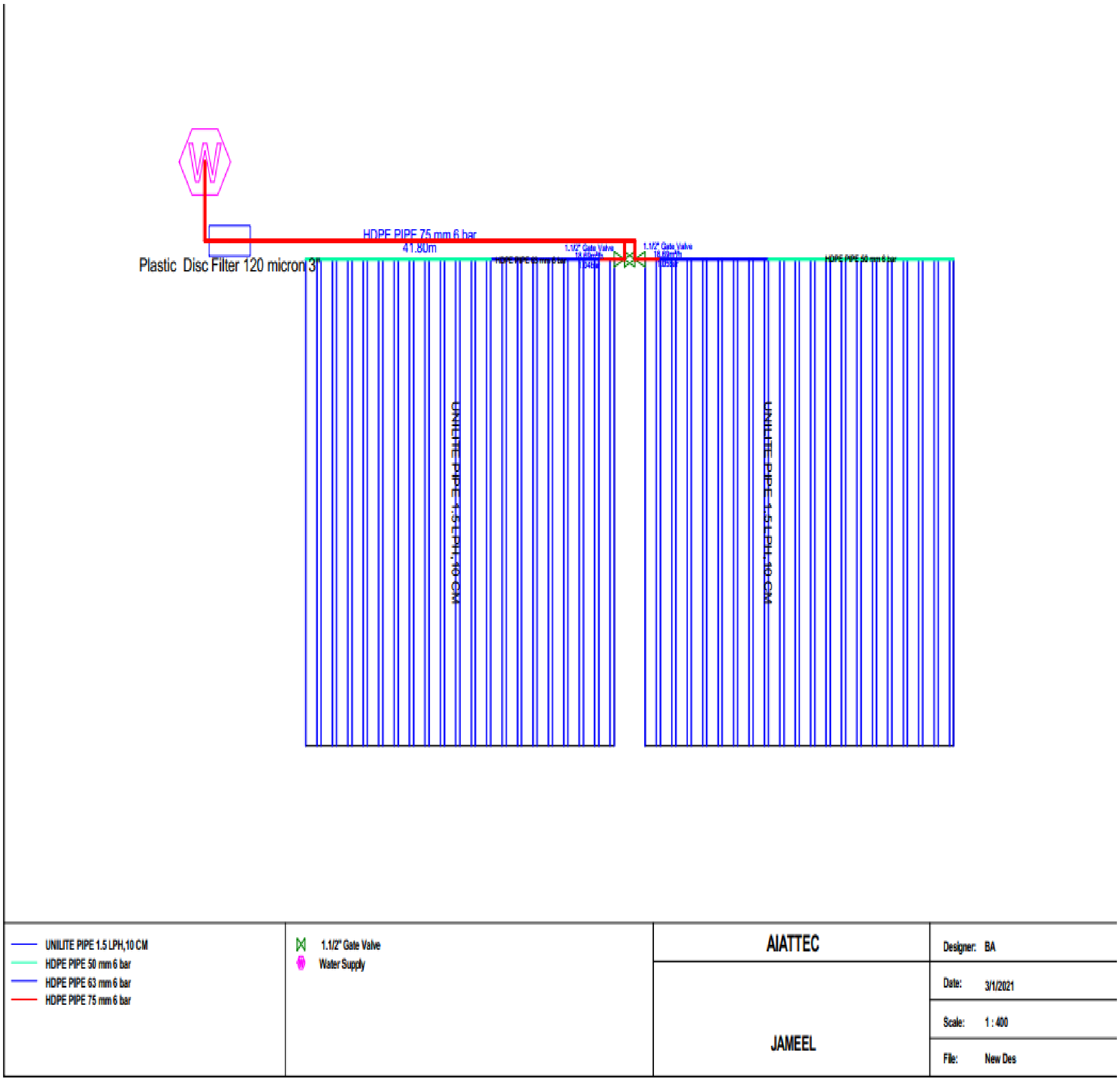

Figure 5.27 Layout diagram of main, semi-main pipes, and laterals lines in the study area.

Irricad Version 19.0 **Mainline Design Pipe Report** 3/1/2021

Company : AIATTEC **Designer :** BA
Client : JAMEEL **Design Date :** 3/1/2021
Site : **Report Date :** 3/1/2021 14:24:13

Notes :

File : New Des..dez

System Flow - 1
Main Supply : Supply no. 1 **Flow :** 18.69 (m3/h) **Pressure :** 1.18 (bar)

Pipes

From X (m)	From Y (m)	From Z (m)	To X (m)	To Y (m)	To Z (m)	Depth (mm)	Pressure (bar) Start	Pressure (bar) End	Flow (m3/h) Allowable	Flow (m3/h) Start	Flow (m3/h) End	Size (mm)	Code
-11.4	67.7	0.0	-11.4	62.5	0.0	0.00	1.2	1.2	5.9	18.7	18.7	90.00	HDP
-11.4	62.5	0.0	-9.0	62.5	0.0	0.00	1.2	1.2	5.9	18.7	18.7	90.00	HDP
-9.0	62.5	0.0	29.4	62.5	0.0	0.00	1.1	1.1	5.9	18.7	18.7	90.00	HDP
29.4	62.5	0.0	30.4	62.5	0.0	0.00	1.1	1.1	5.9	18.7	18.7	90.00	HDP
30.4	62.5	0.0	30.4	61.3	0.0	0.00	1.1	1.0	5.9	18.7	18.7	90.00	HDP
29.4	62.5	0.0	29.4	61.3	0.0	0.00	1.1	1.1	5.9	-0.0	-0.0	90.00	HDP

Figure 5.28 The result of the design of the mainline of the pipe such as flow and pressure in multiple clips.

Irricad Version 19.0 **Water Requirements Report** 3/1/2021

Company : AIATTEC **Designer :** BA
Client : JAMEEL **Design Date :** 3/1/2021
Site : **Report Date :** 3/1/2021 14:02:02

Notes :

File : New Des..dez

Cycle Time is 1 day Times are per cycle

Zone/Area Name	Flow (m3/h)	Area Dunam	Depth Applied (mm)	Depth Required (mm)	Volume Applied (l)	Volume Required (l)
Area no. 1	19.680	0.96	20.5000	8.00	19680.00	7680.00
Area no. 1	19.680	0.96	20.5000	8.00	19680.00	7680.00

Zone/Area Name	Flow (m3/h)	Area Dunam	Depth Applied (mm)	Depth Required (mm)	Volume Applied (l)	Volume Required (l)
Area no. 2	19.680	0.96	20.5000	8.00	19680.00	7680.00
Area no. 2	19.680	0.96	20.5000	8.00	19680.00	7680.00

Figure 5.29 The all water requirements of plants in the design area.

Irricad Version 19.0 **System Duty Report** 3/1/2021

Company :	AIATTEC	**Designer :**	BA
Client :	JAMEEL	**Design Date :**	3/1/2021
Site :		**Report Date :**	3/1/2021 14:26:22
Notes :			
File :	New Des..dez		

Water Supply : **Supply no. 1**

Duty Number	On time	Off time	Pressure (bar)	Flow (m3/h)
1	1 : 0 : 0	1 : 1 : 0	1.18	18.69
2	1 : 1 : 0	1 : 2 : 0	1.17	18.69

Figure 5.30 The system duty of design (pressure and flow).

Irricad Version 19.0 **Bill of Materials** 3/1/2021

Company :	AIATTEC	**Designer :**	BA
Client :	JAMEEL	**Design Date :**	3/1/2021
Site :		**Report Date :**	3/1/2021 14:26:45
Notes :			

Length/Number (m)	Description
2624	UNILITE PIPE 1.5 LPH,10 CM
36	HDPE PIPE 50 mm 6 bar
21	HDPE PIPE 63 mm 6 bar
5	HDPE PIPE 75 mm 6 bar
50	HDPE PIPE 90 mm 6 bar
2	1.1/2" Gate Valve
76	Driplite Elbow Take-off with Rubber 16
82	17mm Adritape Terminal - End Stop
1	PP Elbow Quick Coupling 90mm
1	PP Elbow Quick Coupling 110mm

Figure 5.31 List in the bill of materials necessary in the design by programs.

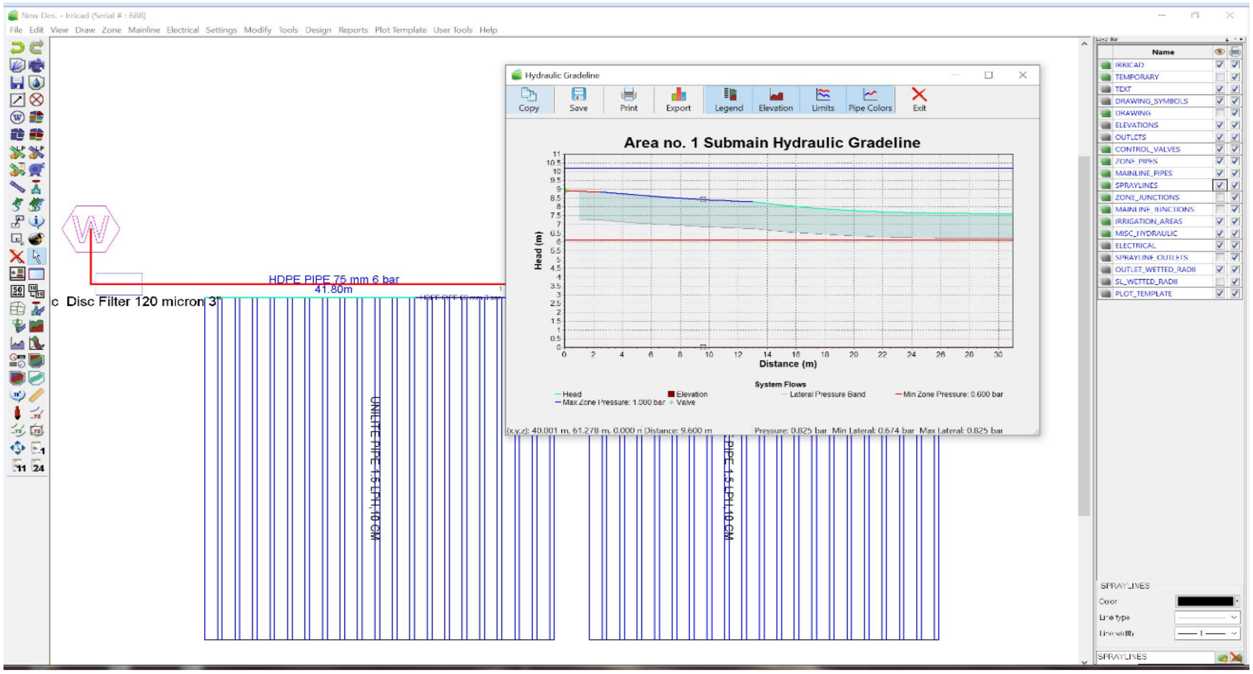

Figure 5.32 The hydraulic grade line for Sub main

System Flow - 1

Zones Operating

Zone Name	(X,Y) (m)		Valve Pressure (bar)	Required Pressure (bar)	Flow (m3/h)
Area no. 1	30.4	61.3	1.0	1.0	18.7

Water Supplies

Water Supply	(X,Y) (m)		Pressure (bar)	Flow (m3/h)
Supply no. 1	-11.4	67.7	1.2	-18.7

System Flow - 2

Zones Operating

Zone Name	(X,Y) (m)		Valve Pressure (bar)	Required Pressure (bar)	Flow (m3/h)
Area no. 2	29.4	61.3	1.0	1.0	18.7

Water Supplies

Water Supply	(X,Y) (m)		Pressure (bar)	Flow (m3/h)
Supply no. 1	-11.4	67.7	1.2	-18.7

Figure 5.33 The valve pressure and required pressure for zones operating.

Irricad Version 19.0 **Zone Control Valve Summary** 3/1/2021

Company :	AIATTEC	**Designer :**	BA
Client :	JAMEEL	**Design Date :**	3/1/2021
Site :		**Report Date :**	3/1/2021 14:04:04
Notes :			
File :	New Des..dez		

Zone Name	Valve Description	Zone Flow (m3/h)	Zone Pressure (bar)
Area no. 1	1.1/2" Gate Valve	18.69	0.88
Area no. 2	1.1/2" Gate Valve	18.69	0.87

Figure 5.34 Summary zone control valve for study area.

Irricad Version 19.0 **Zone Design Report** 3/1/2021

	Allowable Flow (lph)	Actual Flow (lph)	Allowable Pressure (bar)	Actual Pressure (bar)
Minimum Outlet	1.34	1.35	0.60	0.61
Maximum Outlet	1.67	1.57	1.00	0.87
Outlet Variation (%)	19.63	14.09	40.00	29.88

Coefficient of variation = 0.050 Mean Emitter Flow = 1.41 No. of Emitters per Plant = 1

Cu = 97.3 (%) Eu = 89.9 (%) Du = 96.0 (%)

Oulet Locations (X,Y) Minimum : -1.6 , 29.3 Maximum : 28.4 , 61.3

Figure 5.35 The zone design allowable and actual for flow and pressure.

Irricad Version 19.0 **Zone Design Pipe Report** 3/1/2021

Company : AIATTEC **Designer :** BA
Client : JAMEEL **Design Date :** 3/1/2021
Site : **Report Date :** 3/1/2021 14:05:58
Notes :

File : New Des..dez

Area no. 1
Flow : 18.69 (m3/h) **Pressure Upstream:** 1.0 **Downstream:** 0.9 (bar)
Run Type : LP Design

Pipes

From X (m)	From Y (m)	From Z (m)	To X (m)	To Y (m)	To Z (m)	Depth (mm)	Pressure (bar) Start	Pressure (bar) End	Pressure (bar) Allowable	Flow (m3/h) Start	Flow (m3/h) End	Size (mm)	Code
30.4	61.3	0.0	31.4	61.3	0.0	0.0	0.9	0.9	5.9	18.7	18.7	75.0	HDP
31.4	61.3	0.0	31.4	29.3	0.0	0.0	0.9	0.7	1.2	0.5	0.0	17.0	LDP
31.4	61.3	0.0	32.5	61.3	0.0	0.0	0.9	0.9	5.9	18.2	18.2	75.0	HDP
32.5	61.3	0.0	32.5	29.3	0.0	0.0	0.9	0.7	1.2	0.5	0.0	17.0	LDP
32.5	61.3	0.0	32.9	61.3	0.0	0.0	0.9	0.9	5.9	17.8	17.8	75.0	HDP
32.9	61.3	0.0	32.9	29.3	0.0	0.0	0.9	0.7	1.2	0.5	0.0	17.0	LDP
32.9	61.3	0.0	34.0	61.3	0.0	0.0	0.9	0.9	5.9	17.3	17.3	63.0	HDP
34.0	61.3	0.0	34.0	29.3	0.0	0.0	0.9	0.7	1.2	0.5	0.0	17.0	LDP

Page 1

Figure 5.36 Results of pipes design in the study area.

Where: HDP is high density polyethylene

Chapter Six

Conclusions and recommendations

6.1 Conclusions

Irrigation systems have been evaluated, which are produced locally, imported which used are extensively by farmers in Karbala governorate in Iraq.

1. The results of various parameters such as application efficiency (E_a), emissions uniformity in the field (EU_f), uniformity of design emission (EU_d), statistical uniformity coefficient (US_c) were of low values for local products and classified as acceptable, while imported products were classified as good using emitter No 1. When using emitter, No 2, the local products were classified as (Good), and imported products were classified as (Excellent).

2. Coefficient of variation (c_v) value for drippers No 1 was high for local products and was classified as (acceptable), this value decreased and was classified as (very good) when the pressure increased to 1 bar, while was low in the imported product for all pressure and was classified as (very good). When dripper No 2 was used, the results were better than for emitter No 1 and were classified as (Very good to Excellent) when using local products while the imported product was better than the local products because the (c_v) values of the imported product were low at all pressures used and were classified as (Excellent).

3. The value of statistical uniformity coefficients (SU_c) was low and classified as (Fair to very good) when using local products and dripper No 1. While the imported product, (SU_c) value was high and classified as (very good) at all pressures (0.6,0.8,1, bar). When using emitter No2, the value of (SUc) was high and was classified as (Very good to Excellent) for all lateral lines local and imported products.

4. The Irricad program was used to design a part of an existing farm for the ease of the program and to give more realistic results. The results of the Irricad program design were less than the user on the drip irrigation system on the farm, the results of the design (mainline75mm, Subline 50m, gate valve1.1/2˝)while the user field is(mainline 101.6mm , Subline 76.2mm,gate valve 2.1/2˝).

6.2 Recommendations for operating the system

From the results and conclusions drawn from this study, the following recommendations could be suggested

1. The drip irrigation system is beneficial in the consumption of water; it is necessary to choose a suitable dripper to achieve the best results and the exclusion of bad emitter from the drip irrigation.
2. Choosing a suitable operating pressure to ensure the optimum working of the system.
3. The emitters must be cleaned regularly to avoid clogging of the emitters and thus an uneven distribution of the discharge.
4. It has been observed that wells water with high salts is used to irrigate farms using a drip system, which causes clogging of emitters. It is recommended to use river water, and filters must be installed in each of the farms.
5. Noticed during the work that there is a difference in diameters of the local products of drip irrigation pipes from what they are designed on, which causes problems for farmers during the work of tightening and installing the pipes of the system so needed to development for compete with imported products, as well as attention to pipe diameters to facilitate the work of farmers.

6.3 Recommendations for further studies

1. Using a program other than Irricad to design and evaluate drip systems for some drip systems in the governorate's farms.

2. Studying the relationship between processing and productivity could be carried out.

3. It is possible to investigate the effect of the high amount of salts on the work of drip irrigation systems and the extent of their impact on the blockage of emitters.

List of references

A. Almajeed A. Alabas, M. (2013) 'Evaluation the Hydraulic Performance of Drip Irrigation System with Multi Cases', *Global Journal of Researches In Engineering*, 13(2), pp. 13–18. Available at: http://www.engineeringresearch.org/index.php/GJRE/article/view/836.

Abbott, C. L. and Quosy, D. E. D. El (1996) 'Soil Salinity Processes Under Drainwater Reuse in the Nile Delta , Egypt,Report OD/133 March 1996', *Water Management*, (March).

Abd, Mohamed Fadlalla, Alla Elradi Moniem, Abdel Mohamed, Elamin (2006) 'Evaluation of the Performance of Pressure Compensating Drippers in Drip Irrigation System' Khartoum Journal for Engineering Sciences.

Abdulhadi, J. S. and Alwan, H. H. (2020) 'Evaluation the existing drip irrigation network of Fadak Farm' Kerbala Journal for Engineering Sciences.

Al-Ghobari, H. M. (2007) 'Field evaluation of drip irrigation systems in Saudi Arabia', *WIT Transactions on Ecology and the Environment*, 103, pp. 583–592. doi: 10.2495/WRM070541.

Alabas, M. A. A. A. (2013) 'Evaluation the hydraulic performance of drip irrigation system with multi cases', *Global Journal of Research In Engineering*.

Allen R. G. (1996) 'Relating the hazen-williams and darcy-weisbach friction', 12(4), pp. 685–693 American Society of Agricultural Engineers 0883-8542.

Amoo, M. O. Ademiju, T. A. Adesigbin, A. J. Ali, G. A. (2019) 'Performance Evaluation of Drip Irrigation Systems on Production of Okra (Hibiscus esculentus) in Southwestern, Nigeria', *Journal of Engineering Research and Reports*, 5(3), pp. 1–10. doi: 10.9734/jerr/2019/v5i316928.

List of references

Ankidawa, B. . and Zakariah, D. . (2018a) 'Design and Evaluation of Drip Irrigation System for Date Palm Plantations in MAUTECH, Yola, Adamawa State, Northeastern Nigeria ARTICLE INFO ABSTRACT', *Journal of Computational Engineering and Physical Modeling Journal homepage: of Computational Engineering and Physical Modeling*, 1(2), pp. 70–82. doi: 10.22115/CEPM.2018.134525.1030.

Ankidawa, B. . and Zakariah, D. . (2018b) 'Design and Evaluation of Drip Irrigation System for Date Palm Plantations in MAUTECH, Yola, Adamawa State, Northeastern Nigeria ARTICLE INFO ABSTRACT', *Journal of Computational Engineering and Physical Modeling Journal homepage: of Computational Engineering and Physical Modeling*, 1(2), pp. 70–82. Available at: http://creativecommons.org/licenses/BY/4.0/%0Ahttp://www.jcepm.com/.

Asif, M.,, M. Ahmad, A. G. Mangrio, G. Akbar, A. H. Memon (2015) 'Design, evaluation and irrigation scheduling of drip irrigation system on citrus orchard', *Pakistan Journal of Meteorology*, 12(23), pp. 1–12. Available at: http://www.pmd.gov.pk/rnd/rndweb/rnd_new/journal/vol12_issue23_files/Design_Evaluation_and_Irrigation_Scheduling_of_Drip_Irrigation_System_on_Citrus_Orchard.pdf.

Asif, M. (2015) 'Design, Evaluation and Irrigation Scheduling of Drip Irrigation System on Citrus Orchard', *Pakistan Journal of Meteorology*, 12(23), pp. 37–48.

Azizi, N. R., Yasari, E. and Kakularimi, A. (2013) 'Evaluation of Drip Irrigation in the Province of Mazandaran of Northern Iran a Case Study on the City of Babol', *Agricultural and Crop Science*, 6(8), pp. 522–528. Available at: www.ijagcs.com.

Bralts, V. F., Edwards, D. M. and Wu, I. P. (1987) 'Drip irrigation design and evaluation based on the statistical uniformity concept', *Advances in irrigation*, 4, pp.

67–117.

Brouwer, C. Prins, K.Kay, M.Heibloem, M. (1988) ‘Training Manual No. 5 - Irrigation Methods’, *Irrigation Water Management*, (5), p. 140. Available at: https://s3.amazonaws.com/academia.edu.documents/35215643/Irrigation_Methods.1.pdf?response-content-disposition=inline%3B filename%3DIrrigation_Water_Management_Irrigation_M.pdf&X-Amz-Algorithm=AWS4-HMAC-SHA256&X-Amz-Credential=ASIATUSBJ6BAB47UCUOV%2F20200.

Christiansen, J. E. (1942) *Irrigation by sprinkling*. University of California Berkeley.

Dasberg, S. and Dani, O. (1999) *Applied Agricullture : Drip Irrigation*.

Deekshithulu Gowtham, N. V. et al. (2017) ‘Design of Computer Aided Drip Irrigation System Software’, International Journal of Current Microbiology and Applied Sciences. Excellent Publishers, 6(12), pp. 108–118. doi: 10.20546/ijcmas.2017.612.015.

EL-NEMR (2012) ‘an Interactive Spreadsheet for Drip Irrigation System Uniformity Parameters Evaluation’, *International Journal of Agriculture Sciences*, 4(4), pp. 216–220. doi: 10.9735/0975-3710.4.4.216-220.

Elamin, A W M Abd Eldaiam, A M Abdalla, N A Hussain, M.E. (2017) ‘Hydraulic performance of drip irrigation system under different emitter types , and operating pressures using treated wastewater at Khartoum state’, *Hydraulic International Journal of Development and Sustainability*, 6(9), pp. 1086–1095.

Elobeid, A. M. (2006) ‘Hydraulic aspects on the design and performance of drip irrigation system’. M. Sc. Thesis, University of Khartoum, Khartoum Sudan.

List of references

Hoseini, Y. and Delavari, A. (2016) 'Comparing the suitability of two methods (surface and drip) of irrigation based on a parametric evaluation system Comparing the Suitability of Two Methods (Surface and Drip) of Irrigation Based on a Parametric Evaluation System', Araştırma Makalesi/Research Article (Original Paper) 2016, 26(2): 152-160

Howell, Howell, T.A. Stevenson, D.S. Aljibury.F.K. Gitlin, M. Harris Wu, I-Pai Warick, A.W.Raats, P.A.C. (1980) 'Design and operation of trickle (drip) systems.', *American Society of Agricultural Engineers*. American Society of Agricultural Engineers., 10, pp. 633–717.

Howell, Wu, I.-P., , T. A. and Hiler, E. A. (1979) 'Hydraulic Design of Drip Irrigation Systems', (105), p. 80. Available at: https://core.ac.uk/download/pdf/19333341.pdf.

İncİman, A. R. and Acar, B. (2020) 'WATERING UNIFORMITY OF DRIP IRRIGATION SYSTEMS USING IN IRRIGATION OF MAIZE FOR KONYA-ÇUMRA PROVINCE , TURKEY D q ù UC = ê (1 - (qmean û ë EU = x 100', 63(1), pp. 41–44.

Jamrey, P. K. and Nigam, G. K. (2017) 'Performance evaluation of drip irrigation systems', *The Pharma Innovation Journal*, 7(1), pp. 346–348.

Kaushal, A., Patole, R. and Singh, K. G. (2012) 'Drip irrigation in sugarcane: A review', *Agricultural Reviews*. Agricultural Research Communication Centre, 33(3), pp. 211–219.

Keller, J. and Karmeli, D. (1973) 'Trickle Irrigation Design'.Rain Bird sprinkler Manufacturing Corporation Glendora ,California 91740 U.S.A

Keller, J. and Bliesner, R. D. (1990) *Sprinkle and Trickle Irrigation*, *Sprinkle and*

Trickle Irrigation. Springer US. doi: 10.1007/978-1-4757-1425-8.

Khalil, T. M. *et al*. (2020) 'Evaluating hydraulic performance of locally available drip emitters used in Pakistan', *Sarhad Journal of Agriculture*, 36(1), pp. 185–191. doi: 10.17582/journal.sja/2020/36.1.185.191.

Li, Y. *et al*. (2006) 'Hydraulic characterizations of tortuous flow in path drip irrigation emitter', *Journal of Hydrodynamics, ser. B*. Elsevier, 18(4), pp. 449–457.

Li, Y., Liu, Y. and Zhou, B. (2014) 'Eight emitters clogging characteristics and its suitability under on-site reclaimed water drip irrigation Eight emitters clogging characteristics and its suitability under on-site reclaimed water drip irrigation', ResearchGate Springer Article in Irrigation Science ·March 2014 DOI: 10.1007/s00271-013-0420-2

Merriam, J. L. and Keller, J.. (1978) Farm Irrigation System Evaluation : A Guide for Management. UTAH State Universty. Logan, Utah, USA.

Michael, A. M. (1978) *Irrigation: theory and practice.* Vikas publishing house.

Mistry Pranav, Memon Akil, T.M.V. Suryanarayana, D. F. P. P. (2017) 'International Journal of Advance Engineering and Research EVALUATION OF DRIP IRRIGATION SYSTEM FOR DIFFERENT', Scientific Journal of Impact Factor (SJIF), (May), pp. 63–69.

Mohamed ,Rihan, A. A., T. A. and Alawee, W. H. (2021) 'Physical Simulation for the Flow in Straight and Rectangular Loop Manifolds', Journal of Engineering, 27(3), pp. 15–32.

Mostafa, E. A. (2004) 'Correction Factor for Friction Head Loss Through'. Eighth International Water Technology Conference, IWTC8 2004, Alexandria, Egypt,pp.735-749.

Mostafa, H. M. S. (2015) 'Hydraulic Analysis of Biodegradable Drip Irrigation Laterals', (September). International Journal of Agricultural Science and Research (IJASR) ISSN(P): 2250-0057; ISSN(E): 2321-0087 Vol. 4, Available at: http://www.researchgate.net/publication/271446728_

Narayanamoorthy, A., Bhattarai, M. and Jothi, P. (2018) 'An assessment of the economic impact of drip irrigation in vegetable production in India', *Agricultural Economics Research Review*, 31(1), p. 105. doi: 10.5958/0974-0279.2018.00010.1.

Omran, K. and H. (2016) 'Evaluation the Operation of a Drip Irrigation System in Different Types of Soil', *Kufa Journal of Engineering*, 7(2), pp. 104–121.

Opar, S. O., Gichuki, F. and Ondieki, S. . (2014) 'Assessment of Low-head Drip Irrigation Systems Uniformity of Application', *International Journal of Sciences: Basic and Applied Research (IJSBAR) International Journal of Sciences: Basic and Applied Research*, 15(2), pp. 234–244. Available at: http://gssrr.org/index.php?journal=JournalOfBasicAndApplied.

Omran, Kareem and Hassan (2016) 'Evaluation the Operation of a Drip Irrigation System in Different Types of Soil', Kufa Journal of Engineering, 7(2).

Omofunmi Eric, O., Ayodele Ilesanmi, O. and Orisabinone, T. (2019) 'Performance Evaluation of Hydraulic Parameters of a Developed Drip Irrigation System', Malaysian Journal of Civil Engineering, 31(2), pp. 9–16. doi: 10.11113/mjce.v31n2.556.

Oron, S. and Walker, F. (1981) 'Optimal Design and Operation of Permanent Irrigation Systems, water resources research, VOL. 17, NO. 1, pages 11-17.

List of references

Ortega, J., Tarjuelo, J. and de Juan, J. (2002) 'Evaluation of Irrigation Performance in Localized', the Cigr Journal of Scientific Research and Development. Manuscript LW 01 007. Vol IV. 2002 IV, pp. 1–17.

Phocaides, A. (2001). FAO. Handbook on pressurized irrigation techniques.

Food and Agricultural organization of the United Nations, Rome, pp:11-94.

Pragna, G. (2017) 'Hydraulic Performance Evaluation of Drip System by Developing Relationship between Discharge and Pressure', *International Journal of Pure & Applied Bioscience*, 5(4), pp. 758–765. doi: 10.18782/2320-7051.4071.

Purohit R.C., C. K. A., P.K. Singh, L. K. D. and Kothari, M. (2017) 'Performance Evaluation of Drip Irrigation Systems', International Journal of Current Microbiology and Applied Sciences, 6(4), pp. 2287–2292. doi: 10.20546/ijcmas.2017.604.266.

Raphael, O. D. *et al*. (2018) 'Field evaluation of gravity-fed surface drip irrigation systems in a sloped greenhouse', *International Journal of Civil Engineering and Technology*, 9(10), pp. 536–548.

Robert, A. S. (2005) 'Irrigation of vegetable and small fruit crops', *Natural Resource Engineering Specialist, University of Missouri Extension*.

Rowan, M. (2016) 'Evaluation of Drip Irrigation Emitters Distributing Primary and Secondary Wastewater Effluents', *Irrigation & Drainage Systems Engineering*. OMICS Publishing Group, 2(3). doi: 10.4172/2168-9768.1000111.

Sarker *et al*. (2019) 'Development and Evaluation of an Emitter with a Low-Pressure Drip-Irrigation System for Sustainable Eggplant Production', *AgriEngineering*, 1(3), pp. 376–390. doi: 10.3390/agriengineering1030028.

Sharu, E. H. and Ab Razak, M. S. (2020) ‘Hydraulic performance and modelling of pressurized drip irrigation system’, *Water (Switzerland)*, 12(8), pp. 1–88. doi: 10.3390/w12082295.

Solomon, K. (1979) ‘Manufacturing variation of trickle emitters’, *Transactions of the ASAE*. American Society of Agricultural and Biological Engineers, 22(5), pp. 1034–1038.

Soomro, K. B. *et al*. (2013) ‘Evaluate the performance of drip irrigation and discharge of emitters at Coastal area of GadapSindh’, *Global Advanced Research Journal of Engineering, Technology and Innovation*, 2(9), pp. 259–275. Available at: http://garj.org/garjeti/index.htm.

Thompson, E. J. (2009) ‘Hydraulics of IDEal drip irrigation systems’.

Tyson, T. . and Curtis, L. . (2009) ‘Evaluating Water Distribution Uniformity in Micro?Irrigation Systems’, *Biosystems Engineering*.

Valiantzas, J. D. (2005) ‘for Friction and Local Head Losses along Irrigation Laterals’, JOURNAL OF IRRIGATION AND DRAINAGE ENGINEERING *Managing*, (August), pp. 342–350.

Valipour, M. (2012) ‘Sprinkle and Trickle Irrigation System Design Using Tapered Pipes for Pressure Loss Adjusting’, *Journal of Agricultural Science*, 4(12). doi: 10.5539/jas.v4n12p125.

Yan, D.Yang, P.Rowan, M.Ren, S.Pitts, D. (2010) ‘BIOFILM ACCUMULATION AND STRUCTURE IN THE FLOW PATH OF DRIP EMITTERS USING RECLAIMED WASTEWATER’, American Society of Agricultural and Biological Engineers ISSN 2151-0032, pp. 751–758.

List of references

Zamaniyan, M., Fatahi, R. and Boroomand-Nasab, S. (2014) 'Field performance evaluation of micro irrigation systems in Iran', *Soil and Water Research*, 9(3), pp. 135–142. doi: 10.17221/8/2013-swr.

Appendix A

Table A1-1: The quantities of measured water flowing from the emitter of the (local product1)operating pressure(1 bar) and emitter type one.

lateral line.	No. of emitter.	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	470	1	470	28.2
	13	430	1	430	25.8
	24	400	1	400	24
	30	380	1	380	22.8
	36	360	1	360	21.6
	42	330	1	330	19.8
	47	310	1	310	18.6
	53	300	1	300	18
	59	290	1	290	17.4
	66	280	1	280	16.8
	73	275	1	275	16.5
	82	270	1	270	16.2

Table A1-2: The quantities of measured water flowing from the emitter of the (local product 1)operating pressure(1 bar) and emitter type one.

lateral line.	No.of emitter.	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	470	1	470	28.2
	13	430	1	430	25.8
	24	410	1	410	24.6
	30	380	1	380	22.8
	36	370	1	370	22.2
	42	350	1	350	21
	47	340	1	340	20.4
	53	320	1	320	19.2
	59	310	1	310	18.6
	66	300	1	300	18
	73	290	1	290	17.4
	82	280	1	280	16.8

Table A2-1: The quantities of measured water flowing from the emitter of the (local product 2) when the pressure=1 bar and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	480	1	480	28.8
	13	440	1	440	26.4
	24	420	1	420	25.2
	30	390	1	390	23.4
	36	360	1	360	21.6
	42	350	1	350	21
	47	330	1	330	19.8
	53	320	1	320	19.2
	59	310	1	310	18.6
	66	300	1	300	18
	73	295	1	295	17.7
	82	290	1	290	17.4

Table A2-2: The quantities of measured water flowing from the emitter of the (local product 2) when the pressure=1 bar and emitter type one.

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	480	1	480	28.8
	13	450	1	450	27
	24	410	1	410	24.6
	30	390	1	390	23.4
	36	370	1	370	22.2
	42	360	1	360	21.6
	47	340	1	340	20.4
	53	330	1	330	19.8
	59	320	1	320	19.2
	66	310	1	310	18.6
	73	300	1	300	18
	82	290	1	290	17.4

Appendix

Table A3-1: The quantities of measured water flowing from the emitter of (imported product) when the pressure=1 bar and emitter type one**.**

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	475	1	475	28.5
	13	430	1	430	25.8
	24	400	1	400	24
	30	385	1	385	23.1
	36	370	1	370	22.2
	42	360	1	360	21.6
	47	350	1	350	21
	53	345	1	345	20.7
	59	335	1	335	20.1
	66	330	1	330	19.8
	73	325	1	325	19.5
	82	320	1	320	19.2

Table A3-2: The quantities of measured water flowing from the emitter of (imported product) when the pressure=1 bar and emitter type one.

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	470	1	470	28.2
	13	440	1	440	26.4
	24	420	1	420	25.2
	30	400	1	400	24
	36	395	1	395	23.7
	42	380	1	380	22.8
	47	370	1	370	22.2
	53	360	1	360	21.6
	59	350	1	350	21
	66	345	1	345	20.7
	73	335	1	335	20.1
	82	330	1	330	19.8

Table A4-1: The quantities of measured water flowing from the emitter of the (local product 1) when the pressure (0.8 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	420	1	420	25.2
	13	390	1	390	23.4
	24	360	1	360	21.6
	30	340	1	340	20.4
	36	320	1	320	19.2
	42	310	1	310	18.6
	47	300	1	300	18
	53	290	1	290	17.4
	59	280	1	280	16.8
	66	260	1	260	15.6
	73	250	1	250	15
	82	240	1	240	14.4

Table A4-2: The quantities of measured water flowing from the emitter of the (local product 1) when the pressure (0.8 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	420	1	420	25.2
	13	380	1	380	22.8
	24	360	1	360	21.6
	30	340	1	340	20.4
	36	330	1	330	19.8
	42	300	1	300	18
	47	290	1	290	17.4
	53	280	1	280	16.8
	59	270	1	270	16.2
	66	260	1	260	15.6
	73	250	1	250	15
	82	235	1	235	14.1

Table A5-1: The quantities of measured water flowing from the emitter of the (local product 2) when the pressure(0.8 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	420	1	420	25.2
	13	380	1	380	22.8
	24	360	1	360	21.6
	30	350	1	350	21
	36	340	1	340	20.4
	42	320	1	320	19.2
	47	290	1	290	17.4
	53	280	1	280	16.8
	59	270	1	270	16.2
	66	260	1	260	15.6
	73	250	1	250	15
	82	240	1	240	14.4

Table A5-2: The quantities of measured water flowing from the emitter of the (local product 2) when the pressure(0.8 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	430	1	430	25.8
	13	380	1	380	22.8
	24	360	1	360	21.6
	30	330	1	330	19.8
	36	320	1	320	19.2
	42	310	1	310	18.6
	47	300	1	300	18
	53	290	1	290	17.4
	59	270	1	270	16.2
	66	260	1	260	15.6
	73	250	1	250	15
	82	240	1	240	14.4

Table A6-1: The quantities of measured water flowing from the emitter of the (imported product) when the pressure(0.8 bar) and emitter type one.

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	430	1	430	25.8
	13	410	1	410	24.6
	24	390	1	390	23.4
	30	360	1	360	21.6
	36	340	1	340	20.4
	42	320	1	320	19.2
	47	310	1	310	18.6
	53	300	1	300	18
	59	290	1	290	17.4
	66	290	1	290	17.4
	73	285	1	285	17.1
	82	280	1	280	16.8

Table A6-2: The quantities of measured water flowing from the emitter of the (imported product) when the pressure(0.8 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	440	1	440	26.4
	13	420	1	420	25.2
	24	390	1	390	23.4
	30	380	1	380	22.8
	36	350	1	350	21
	42	330	1	330	19.8
	47	320	1	320	19.2
	53	310	1	310	18.6
	59	300	1	300	17.4
	66	290	1	290	17.4
	73	285	1	285	17.1
	82	280	1	280	16.8

Table A7-1: The quantities of measured water flowing from the emitter of the (local product 1) when the pressure=(0.6bar) and emitter type one.

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	380	1	380	22.8
	13	360	1	360	21.6
	24	345	1	345	20.7
	30	330	1	330	19.8
	36	280	1	280	16.8
	42	240	1	240	14.4
	47	230	1	230	13.8
	53	220	1	220	13.2
	59	200	1	200	12
	66	200	1	200	12
	73	200	1	200	12
	82	195	1	195	11.7

Table A 7-2: The quantities of measured water flowing from the emitter of the (local product 1) when the pressure=(0.6bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	390	1	390	23.4
	13	350	1	350	21
	24	325	1	325	19.5
	30	310	1	310	18.6
	36	300	1	300	18
	42	275	1	275	16.5
	47	250	1	250	15
	53	230	1	230	13.8
	59	210	1	210	12.6
	66	210	1	210	12.6
	73	200	1	200	12
	82	200	1	200	12

Table A8-1: The quantities of measured water flowing from the emitter of the (local manufacturer 2) when the pressure(0.6bar) and emitter type one.

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	360	1	360	21.6
	13	310	1	310	18.6
	24	290	1	290	17.4
	30	270	1	270	16.2
	36	250	1	250	15
	42	240	1	240	14.4
	47	230	1	230	13.8
	53	220	1	220	13.2
	59	210	1	210	12.6
	66	200	1	200	12
	73	185	1	185	11.1
	82	180	1	180	10.8

Table A8-2: The quantities of measured water flowing from the emitter of the (local product 2) when the pressure(0.6bar) and emitter type one.

lateral line. No	No. of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	350	1	350	21
	13	310	1	310	18.6
	24	270	1	270	16.2
	30	250	1	250	15
	36	230	1	230	13.8
	42	225	1	230	13.8
	47	220	1	220	13.2
	53	210	1	210	12.6
	59	200	1	200	12
	66	190	1	190	11.4
	73	180	1	180	10.8
	82	175	1	175	10.5

Table A9-1: The quantities of measured water flowing from the emitter of the (imported product) when the pressure(0.6 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
1	1	380	1	380	22.8
	13	350	1	350	21
	24	330	1	330	19.8
	30	320	1	320	19.2
	36	310	1	310	18.6
	42	300	1	300	18
	47	280	1	280	16.8
	53	260	1	260	15.6
	59	250	1	250	15
	66	245	1	245	14.7
	73	235	1	235	14.1
	82	230	1	230	13.8

Table A9-2: The quantities of measured water flowing from the emitter of the (imported product) when the pressure(0.6 bar) and emitter type one.

lateral line. No	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
2	1	380	1	380	22.8
	13	360	1	360	21.6
	24	340	1	340	20.4
	30	320	1	320	19.2
	36	300	1	300	18
	42	290	1	290	17.4
	47	280	1	280	16.8
	53	270	1	270	16.2
	59	250	1	250	15
	66	240	1	240	14.4
	73	235	1	235	14.1
	82	230	1	230	13.8

Appendix B

Table B-1: The measured flow rate of emitter type two under pressure 0.5 bar.

Type of lateral	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
Local 1	1	420	1	420	25.2
	5	380	1	400	24
	9	380	1	380	22.8
	12	360	1	360	21.6
	15	340	1	340	20.4
	18	320	1	320	19.2
	21	300	1	300	18
	25	290	1	290	17.4
Local 2	1	440	1	440	26.4
	5	420	1	420	25.2
	9	390	1	390	23.4
	12	360	1	360	21.6
	15	340	1	340	20.4
	18	320	1	320	19.2
	21	310	1	310	18.6
	25	300	1	300	18
Imported	1	450	1	450	27
	5	430	1	430	25.8
	9	410	1	410	24.6
	12	390	1	390	23.4
	15	380	1	380	22.8
	18	360	1	360	21.6
	21	350	1	350	21
	25	345	1	345	20.7

Table B-2: The measured flow rate of emitter type two under pressure 1.5 bar.

Type of lateral	No.of emitter	volume(ml)	Tim(min)	q(ml/min)	q(l/hr.)
Local 1	1	740	1	740	44.4
	5	690	1	690	41.4
	9	660	1	660	39.6
	12	640	1	640	38.4
	15	620	1	620	37.2
	18	600	1	600	36
	21	590	1	590	35.4
	25	570	1	570	34.2
Local 2	1	720	1	720	43.2
	5	680	1	680	40.8
	9	660	1	660	39.6
	12	640	1	640	38.4
	15	610	1	610	36.6
	18	600	1	600	36
	21	590	1	590	35.4
	25	575	1	575	34.5
Imported	1	720	1	720	43.2
	5	710	1	710	42.6
	9	690	1	690	41.4
	12	660	1	660	39.6
	15	650	1	650	39
	18	640	1	640	38.4
	21	635	1	635	38.1
	25	630	1	630	37.8

Appendix C

TableC1-1: The measured pressure and flow rate of emitter type one under pressure 1 bar. Local one.

Type of lateral	No. lateral	No.of emitter	Pressure(bar)	Pressure(m)	Discharge (L/hr.) of emitter
Local 1	1	1	0.95	9.69	28.2
		13	0.85	8.67	25.8
		24	0.73	7.45	24
		36	0.69	7.04	21.6
		47	0.64	6.53	18.6
		59	0.6	6.12	17.4
		73	0.58	5.92	16.5
		82	0.57	5.81	16.5
	2	1	0.95	9.69	28.2
		13	0.81	8.26	25.8
		24	0.72	7.34	24.6
		36	0.69	7.04	22.2
		47	0.63	6.43	20.4
		59	0.59	6.02	18.6
		73	0.58	5.92	17.4
		82	0.57	5.81	16.8

TableC1-2: The measured pressure and flow rate of emitter type one under pressure 1 bar. Local two.

Type of lateral	No. lateral	No.of emitter	Pressure(bar)	Pressure(m)	Discharge (L/hr.) of emitter
Local 2	1	1	0.95	9.69	28.8
		13	0.85	8.67	26.4
		24	0.76	7.75	25.2
		36	0.68	6.94	21.6
		47	0.60	6.12	19.8
		59	0.55	5.61	18.6
		73	0.54	5.51	17.7
		82	0.53	5.41	17.4
	2	1	0.96	9.79	28.8
		13	0.84	8.57	27
		24	0.76	7.75	24.6
		36	0.72	7.34	22.2
		47	0.65	6.63	20.4
		59	0.60	6.12	19.2
		73	0.55	5.61	18
		82	0.54	5.51	17.4

Table C1-3: The measured pressure and flow rate of emitter type one under pressure 1 bar. Imported.

Type of lateral	No. lateral	No.of emitter	Pressure(bar)	Pressure(m)	Discharge (L/hr.) of emitter
Imported	1	1	0.95	9.69	28.2
		13	0.82	8.36	26.4
		24	0.70	7.14	25.2
		36	0.62	6.32	23.7
		47	0.57	5.81	22.2
		59	0.56	5.71	21
		73	0.55	5.61	20.1
		82	0.55	5.61	19.8
	2	1	0.94	9.59	28.5
		13	0.80	8.16	25.8
		24	0.70	7.14	24
		36	0.60	6.12	22.2
		47	0.56	5.71	21
		59	0.55	5.61	20.1
		73	0.55	5.61	19.5
		82	0.55	5.61	19.2

Table C2-1: The measured pressure and flow rate of emitter type one under pressure 0.6 bar.

Type of lateral	No. lateral	No.of emitter	Pressure (bar)	Pressure (m)	Discharge (L/hr.) emitter
Local 1	1	1	0.60	6.12	21
		13	0.58	5.92	18
		24	0.54	5.51	16.8
		36	0.50	5.10	15
		47	0.45	4.59	13.8
		59	0.40	4.08	12
		73	0.38	3.88	9.9
		82	0.35	3.57	9.3
	2	1	0.60	6.12	20.4
		13	0.58	5.92	18.6
		24	0.54	5.51	16.8
		36	0.50	5.10	15
		47	0.46	4.69	13.2
		59	0.40	4.08	12
		73	0.38	3.88	10.2
		82	0.34	3.47	9.6

Table C2-2: The measured pressure and flow rate of emitter type one under pressure 0.6 bar.

Type of lateral	No. lateral	No.of emitter	Pressure (bar)	Pressure (m)	Discharge (L/hr.) emitter
Local 2	1	1	0.60	6.12	21.6
		13	0.58	5.92	18.6
		24	0.55	5.61	17.4
		36	0.52	5.30	15
		47	0.48	4.90	13.8
		59	0.43	4.39	12.6
		73	0.38	3.88	11.1
		82	0.35	3.57	10.8
	2	1	0.60	6.12	21
		13	0.58	5.92	18.6
		24	0.55	5.61	16.2
		36	0.49	5.00	13.8
		47	0.48	4.90	13.2
		59	0.42	4.28	12
		73	0.37	3.77	10.8
		82	0.35	3.57	10.5

Table C2-3: The measured pressure and flow rate of emitter type one under pressure 0.6 bar.

Type of lateral	No. lateral	No.of emitter	Pressure (bar)	Pressure (m)	Discharge (L/hr.) emitter
imported	1	1	0.60	6.12	22.8
		13	0.59	6.02	21
		24	0.57	5.81	19.8
		36	0.52	5.30	18.6
		47	0.46	4.69	16.8
		59	0.39	3.98	15
		73	0.35	3.57	14.1
		82	0.33	3.37	13.8
	2	1	0.60	6.12	22.8
		13	0.59	6.02	21.6
		24	0.58	5.92	20.4
		36	0.52	5.30	18
		47	0.46	4.69	16.8
		59	0.39	3.98	15
		73	0.35	3.57	14.1
		82	0.33	3.37	13.8

Table C3-1: The measured pressure and flow rate of emitter type one under pressure 0.8 bar.

Type of lateral	No. lateral	No.of emitter	Pressure(bar)	Pressure(m)	Discharge (L/hr.) of emitter
Local 1	1	1	0.78	7.96	25.2
		13	0.66	6.73	23.4
		24	0.61	6.22	21.6
		36	0.55	5.61	19.2
		47	0.50	5.10	18
		59	0.48	4.90	16.8
		73	0.46	4.69	15
		82	0.44	4.49	14.4
	2	1	0.78	7.96	25.2
		13	0.65	6.63	22.8
		24	0.60	6.12	21.6
		36	0.55	5.61	19.8
		47	0.52	5.30	17.4
		59	0.48	4.90	16.2
		73	0.46	4.69	15
		82	0.44	4.49	14.1

Table C3-2: The measured pressure and flow rate of emitter type one under pressure 0.8 bar.

Type of lateral	No. lateral	No.of emitter	Pressure(bar)	Pressure(m)	Discharge (L/hr.) of emitter
Local 2	1	1	0.80	8.16	25.2
		13	0.72	7.34	22.8
		24	0.65	6.63	21.6
		36	0.59	6.02	20.4
		47	0.53	5.41	17.4
		59	0.50	5.10	16.2
		73	0.47	4.79	15
		82	0.44	4.49	14.4
	2	1	0.78	7.96	25.8
		13	0.71	7.24	22.8
		24	0.64	6.53	21.6
		36	0.58	5.92	19.2
		47	0.54	5.51	18
		59	0.50	5.10	16.2
		73	0.47	4.79	15
		82	0.44	4.49	14.4

Table C3-3: The measured pressure and flow rate of emitter type one under pressure 0.8 bar.

Type of lateral	No. lateral	No.of emitter	Pressure(bar)	Pressure(m)	Discharge (L/hr.) of emitter
Imported	1	1	0.80	8.16	25.8
		13	0.71	7.24	24.6
		24	0.66	6.73	23.4
		36	0.58	5.92	20.4
		47	0.55	5.61	18.6
		59	0.50	5.10	17.4
		73	0.47	4.79	17.1
		82	0.45	4.59	16.8
	2	1	0.80	8.16	26.4
		13	0.66	6.73	25.2
		24	0.59	6.02	23.4
		36	0.56	5.71	21
		47	0.53	5.41	19.2
		59	0.5	5.10	17.4
		73	0.47	4.79	17.1
		82	0.45	4.59	16.8

Table C 4: The measured pressure and flow rate of emitter type two under pressure 0.5 bar.

Type of lateral	No.of emitter	Pressure (bar)	Pressure (m)	Discharge (L/hr.) of emitter
Local 1	1	0.48	4.90	25.2
	5	0.45	4.59	24
	9	0.43	4.39	22.8
	12	0.40	4.08	21.6
	15	0.39	3.98	20.4
	18	0.38	3.88	19.2
	21	0.37	3.77	18
	25	0.36	3.67	17.4
Local 2	1	0.50	5.10	26.4
	5	0.48	4.90	25.2
	9	0.46	4.69	23.4
	12	0.44	4.49	21.6
	15	0.42	4.28	20.4
	18	0.40	4.08	19.2
	21	0.39	3.98	18.6
	25	0.38	3.88	18
Imported	1	0.49	5.00	27
	5	0.47	4.79	25.8
	9	0.45	4.59	24.6
	12	0.44	4.49	23.4
	15	0.43	4.39	22.8
	18	0.42	4.28	21.6
	21	0.41	4.18	21
	25	0.40	4.08	20.7

Table C-5: The measured pressure and flow rate of emitter type two under pressure 1.5 bar.

Type of lateral	No.of emitter	Pressure (bar)	Pressure (m)	Discharge (L/hr.) of emitter
Local 1	1	1.47	14.99	44.4
	5	1.45	14.79	41.4
	9	1.41	14.38	39.6
	12	1.38	14.08	38.4
	15	1.37	13.97	37.2
	18	1.34	13.67	36
	21	1.32	13.46	35.4
	25	1.3	13.26	34.2
Local 2	1	1.47	14.99	43.2
	5	1.45	14.79	40.8
	9	1.41	14.38	39.6
	12	1.39	14.18	38.4
	15	1.37	13.97	36.6
	18	1.34	13.67	36
	21	1.32	13.46	35.4
	25	1.3	13.26	34.5
Imported	1	1.47	14.99	43.2
	5	1.45	14.79	42.6
	9	1.42	14.48	41.4
	12	1.4	14.28	39.6
	15	1.39	14.18	39
	18	1.37	13.97	38.4
	21	1.34	13.67	38.1
	25	1.32	13.46	37.8

المستخلص:

على الرغم من وجود الأنهار والبحيرات في العراق ،فقد أدى التغير المناخي وبناء السدود في الدول المتشاطئة معه إلى نقص كبير في الموارد المائية ما تطلب ترشيد استهلاك المياه في الزراعة باستخدام أنظمة الري التي يتم من خلالها تحقيق الاستهلاك الأمثل للمياه. تعد طريقة الري بالتنقيط احدى اهم طرق الري التي يتزايد استخدامها من قبل المزارعين ، وهي من أكثر الطرق فعالية في ترشيد استهلاك المياه حيث تدعو الحاجة الى تقييم أداء عملها باستمرار . أجريت هذه الدراسة في مزارع محافظة كربلاء العراقية ، وقد تم إنشاء نظام ري بالتنقيط في إحدى المزارع يتألف من مجموعة انابيب من ثلاثة مناشئ مختلفة ومستخدمة محلياً في مزارع المحافظة اثنان منها محلية والثالث مستورد. معظم المزارع في تلك المناطق الصحراوية مخصصة لزراعة الطماطم والخيار والبصل وتعتمد على مياه الآبار باستخدام نظام الري بالتنقيط. تعد الظروف المناخية في تلك المنطقة قاسية وجافةً. اعتمادًا على قياسات معدلات التصريف والضغط للبواعث ، تم تحديد معاملات مختلفة لشبكة الري بالتنقيط فعند استخدام المنقط رقم (١) كان تناسق الانبعاث الحقلي يتراوح بين (٧٣,٤٪ و ٨٨٪) و تناسق الانبعاثات المطلق يتراوح بين (٧٣٪ و ٨٦٪) اما تناسق الانبعاث التصميمي فيتراوح بين (٧٠,٨٪ و ٨٥,٢٪) وقيمة معامل التجانس الإحصائي تراوح بين (٧٣,٤٪ و٨٨,٦٪) وتراوح معامل التباين بين(٠,١١و٠,٢٦.) في حين تراوحت كفاءة الارواء بين (74٪ و ٨٩٪) وتراوح تغاير تدفق المنقطات (٤٨,٧٪ و ٣٢,٦٪) و وتغاير الضغط بين(٤٠٪ و٤٤,٩%) .عند استخدام المنقط رقم (٢) كان تناسق الانبعاث الحقلي يتراوح بين (٨٤٪ و ٩٥٪) و تناسق الانبعاثات المطلق بين (٨٣٪ و ٩٤٪) اما تناسق الانبعاث التصميمي فتراوح بين (٧٩,٧ ٪ و ٩٣٪) وتراوحت قيمة معامل التجانس الإحصائي (٨٦٪و٩٥٪) في حين كانت قيمة معامل التباين بين (٠,١٣و٠,٠٥) و كفاءة الارواء بين (٨٢,٥٪ و ٩٤٪) اما تغاير تدفق المنقطات فتراوح بين (١٢,٥٪و٣١٪) و تغاير الضغط بين (١٠,٢٪ و٢٥,١٪) .تظهر هذه النتائج أن المنتج المستورد أفضل من المنتج المحلي ، وأن قيم المعاملات المذكورة انفا تتحسن مع زيادة الضغط ، حيث ان أفضل تقييم كان عند الضغط (١ بار) وأن االمنقط رقم(٢) أفضل من منقط رقم (١). ان تغاير الضغط المقاس يتطابق مع المحسوب بنسبة خطأ مطلق يساوي (٠,٠٢-٠,٠٦) وان معامل هازن وليم قد وجد مساويا (١٤٠) للمنتجات المحلية و١٥٠ للمنتج المستورد .تم في هذه الدراسة استخدام برنامج (IRRICAD) لاعادة تصميم جزء من مزرعة متكاملة وتقييم عملها وعند مقارنة النتائج مع التصميم وجد بان الاقطار المستخدمة(الانبوب الرئيسي ١٠١,٦ملم والانبوب الثانوي ٧٦,٢ ملم) تزيد عن المطلوبة في التصميم (الانبوب الرئيسي ٧٥ملم والانبوب الثانوي ٥٠ ملم) وفقا لنتائج البرنامج.

جمهورية العراق

وزارة التعليم العالي والبحث العلمي

جامعة كربلاء

كلية الهندسة

قسم الهندسة المدنية

تقييم أداء أنظمة الري بالتنقيط المنتجة والمستخدمة محليا

رسالة

مقدمة الى قسم الهندسة المدنية/ كلية الهندسة في جامعة كربلاء كجزء من متطلبات نيل درجة ماجستير علوم في الهندسة المدنية

من قبل

جميل رجه رواش

بكالوريوس علوم في الهندسة المدنية / جامعة بابل (٢٠٠٨)

باشراف

الأستاذ الدكتورحسام هادي علوان