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Full Length Research Paper

Evaluate the performance of drip irrigation and discharge of emitters at Coastal area of GadapSindh

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Plant Introduction Centre of Southern-zone Agricultural Research Centre of PARC was carried out the research study at Abdul Wahid farm at Gadap of Karachi. The area is being irrigated by the runoff collected from the catchment of Gadap, which is stored in Thado dam. Mostly the crops are Chiku and bare giving fruits from May to July and the area under study was 3.65 hector (9 acres).The climate in this area is mild to humid and the rainfall range from (180 to 250 mm per year). The soil is sandy and pH range from 7.5 to 8.5. The fruit trees were planted at 40ftx40ft and 35ftx35ft feet and the drip irrigation system consisted of the water source, motor pump, main, submain and lateral line, micro tubes and pressure gauge. The data was collected at the head, mid and tail of the alternate laterals in the command of each sub main. The installation of drip irrigation application requires site survey, layout, Auto CAD layout, designing file which is used to calculate head losses and pump requirements, bill of quantities which have the total system cost, Installation layout, game plan, pictorial plan, installation log book, commissioning paper and project completion certificate. The emitters flow rate was measured by graduated cylinder used to measure the volume collected for a given time with the help of stopwatch. Discharge uniformity was measured to find that how evenly the water is distributed within the installation drip irrigation system.The variation in discharge at the head, mid, and tail of each lateral was due to various factors include clogging of the emitters, slop, size of the emitters, length of lateral lines, leakage of joints and end plugs. The discharge uniformity under different distances of hydrozones from water source on main line basis is 97 % at 79.8 feet of distance among emitters at head, mid and tail on lateral line. On the basis of coefficient of variation the hydrozone 7 is performing well, hydro zone 5 is average, hydro zone 1,2,3,4,9,10,11,12 were marginal and hydrozone 6,8 were in the range of unacceptable. The emission uniformity of each hydrozone was range from 52.28 to 84.65 % with an overall average of 69.53%.Emitters discharge data were collected by volumetric method on lateral line to check whether the system is performing well or not and making of the commissioning paper which has all these details discharge (GPH), position of emitters, no of laterals line and questions about farmers satisfaction.

Keywords : Drip irrigation, Discharge of Emitters, Coastal area of Gadap Sindh

INTRODUCTION

Irrigated agriculture plays a critical role in meeting global food needs. Declining irrigation water supplies threaten the sustainability of irrigated agricultural production in Pakistan.

Irrigation is the scientific application of water to the plants for optimum crop growth and yield. Where the rain fall is less than crop water needs. Irrigation can be done in several ways. In

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Figure 1. Showing main, submain line and jointing valve in the field.

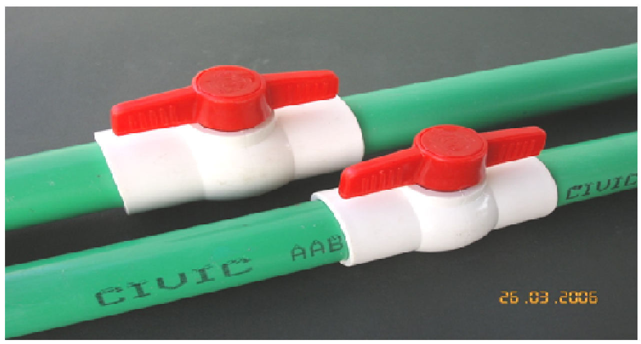

Figure 2. Shows valves on submain and lateral

Figure 3. Shows a measuring gauge that measure the flow of water in (psi)

Pakistan generally surface irrigation is practiced and a lot of water is of water is wasted through seepage losses, deep percolation, runoff and evaporation. The overall efficiency of surface irrigation ranged from 30-40%. Over irrigation adversely affect crop quality and reduce the yield. Pakistan has one of the largest canal irrigation network in the world. About 14 million hectare of the land is irrigated with this system which is nearly 60% of the total cultivated land in the country. The two main crop seasons in Pakistan are Rabi (winter) and Kharif (summer). The crops and their water requirement do not remain the same in these two seasons. The water shortage is increasing day by day and drip irrigation is one of the best methods to reduce the losses in irrigation.

Water is the scarce resource and is available in inadequate amount so its optimal use is essential through drip irrigation which saves water and increases the yield. The proper timing and amount of water to be applied is essential for efficient irrigation. Reduced irrigation cause plant water stress and can reduce crop yield. Where over-irrigation means wastage of water, energy and may lead to leaching of nutrient from root zone, surface soil erosion and lower air content of soil.

Coastal water management is one of the important issue in Sindh area.The length of Pakistan coast is about 1100 kms which ranges from Gawadar in Baluchistan to Badin in Sindh province. The Gadap and Malir district and adjacent districts of Karachi area also comes under thecoastal region.

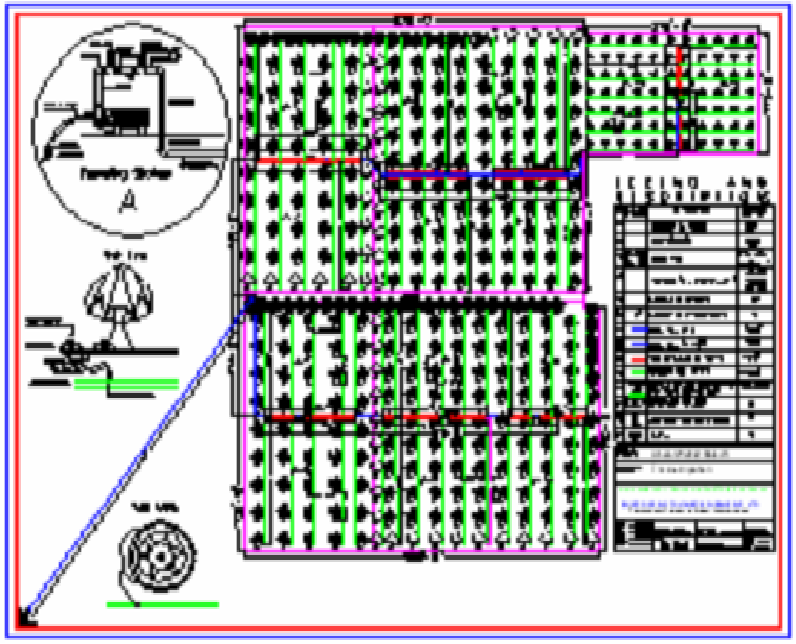

Figure 5. Auto Cad layout of the Study Area

Table 1. The basic farm data for system designing of micro irrigation

Basic Farm Data		
Variables	**UOM**	**Values**
Farmer Name	Text	Akhtar Bagh
Location	Text	Gadap
Crop Type	Text	Chiku
Area of the farm	Acres	9
Cropping Pattern	Feet x Feet	35x35
Total Number of trees	Number	303
Number of trees per acre	Number	34
Current Age of the tree	Year(s)	13
Current Canopy Diameter	Feet	8
Current Peak Water Requirement	Gallons/Day	5
Average Water Requirement	Gallons/Day	4
Tree Maturity Age	Year(s)	17
Mature Tree Canopy Diameter	Feet	21
Peak Water Requirement at Maturity	Gallons/Day	38
Average Water Requirement at Maturity	Gallons/Day	26
Design Process		
Variables	**UOM**	**Values**
System running time keeping in view Peak Water Requirement (PWR) for a mature tree per Hydrozone	Hours	0.8
Total number of blocks.	Number	1
Number of trees in a block.	Number	303
Number of days for which you want to store water for irrigation.	Number	3
Number of Hydrozones in a block.	Number	10
Total system running time for a block	Hours	8
Water storage capacity required per block keeping in view PWR.	Gallons	34,275

Table 2. The water requirement calculation sheet for system designing of micro irrigation.

Water Requirement Calculation Sheet

Variables	Values
Location	Karachi
Eto & Kc Reference City	Karachi
Crop Type	Chiku
Current Canopy (Diameter in Ft)	8
Current Plant Area sq. ft. [Pi x (Canopy Diameter/2)^2]	50
Mature Tree Canopy (Diameter in Ft)	21
Mature Tree Area sq. ft. [Pi x (Canopy Diameter/2)^2]	347
ETCrop Inches to Gallons per Plant Conversion	0.52
Desired Operation time for Peak Requirement (Hours) per Hydrozone	0.80
Suggested Emitting Discharge rate (Tree/GPM)	0.79

Return to Main Menu

Months	*ETo (Inches)	Kc	ET crop inches/day	Current CWR Gallons/Plant/Day	Mature Tree CWR Gallons/Plant/Day	System run time for Current CWR (Minutes)	System run time for Current CWR (Hours)	System run time for Mature Tree CWR (Minutes)	System run time for Mature Tree CWR (Hours)
January	0.13	0.75	0.09	2.5	17.0	3.1	0.05	22	0.36
February	0.15	0.75	0.11	2.9	20.2	3.7	0.06	26	0.43
March	0.19	0.75	0.14	3.8	26.0	4.8	0.08	33	0.55
April	0.25	0.75	0.19	4.9	33.5	6.2	0.10	43	0.71
May	0.28	0.75	0.21	5.5	37.7	7.0	0.12	48	0.80
June	0.26	0.75	0.19	5.0	34.5	6.4	0.11	44	0.73
July	0.20	0.75	0.15	4.0	27.6	5.1	0.09	35	0.59
August	0.19	0.75	0.14	3.7	25.5	4.7	0.08	32	0.54
September	0.20	0.75	0.15	3.9	27.1	5.0	0.08	34	0.57
October	0.20	0.75	0.15	3.9	26.6	4.9	0.08	34	0.56
November	0.15	0.75	0.12	3.0	20.7	3.8	0.06	26	0.44
December	0.13	0.75	0.09	2.5	17.0	3.1	0.05	22	0.36
Average	0.19	0.75	0.15	3.8	26.1	4.8	0.08	33	0.55
Peak	0.28	0.75	0.21	5.5	37.7	7.0	0.12	48	0.80

* Source: Pressurized Irrigation Systems and Innovative Adaptations Hand Book, WRRI

+Irrigation Water Management: Training Manual No. 3 FAO Publications

Since, about 50 to 55% of available surface water is being lost due to mismanagement i.e. losses in irrigation system including seepage from earthen canals and water courses, unleveled fields and following traditional practices, therefore, to sustain agricultural activities and food security for the growing population of the country, we have to overcome the irrigation losses and conserve water by adopting innovative irrigation techniques such as xerigation which is low volume irrigation system like drip, sprinkler, subsurface, bubbler etc based on consumptive use of water. These innovative irrigation techniques are well known for high water application and water use efficiency and are capable to save about 50 to

60% water in comparison to those of traditional irrigation methods. Apart from this, to bring more land under plough and rehabilitate large tracts of saline land, marginal quality ground waters are to be exploited and its safe use for cultivation of different crops is to be established, so that more food and fiber could be produced for growing population of the country.

Drip irrigation system has become very popular of micro irrigation and involves dripping water on to the soil at very low rates (1 to 6 gph) from a system of small diameter (3 to 5 mm) polyethylene pipes fitted with outlets called emitters. Water application is made frequently and irrigation interval varies from 1-3 days which provides a very favorable high moisture level around the plant root zone nearly at soil field capacity.

This irrigation system has many desirable features, like higher yield, improved crop quality and reduction in water and energy use. It can increase crop yield from 10 to 50% as compared to other methods of irrigation. In addition to that there is evidence that the quality of some crops have been improved by trickle irrigation. There is less deep percolation, runoff and evaporation (i.e. higher application efficiencies) due to a portion of the potential root zone irrigation

Drip irrigation system usually uses less water than other types of irrigation systems. This system consists of several components in which water is pumped into it. The flow is passing through valves, filters main line, sub main or manifold

Table 3. Shows the friction loss calculation for sub main pipe for system designing of micro irrigation.

Friction Loss Calculation for Sub Main Pipe

Block Number		1
Hydrozone Numbers	1to10	
Design Parameters	**UOM**	**Values**
Number of hydrozones in the block.	Number	10
Number of trees in the block.	Number	303
Sub Main Pipe ID (Inches)	Inches	1 1/4
Maximum length of Sub Main Pipe	Feet	250
Required flow rate	GPM	27.49
Pressure loss in the Sub Main Pipes	Feet	10.94

Friction Loss Calculation

C	215			
D	1 1/4	Inches	0.04	In meters
Q	27.49	GPM	2.08E-03	In m^3/Sec
L	250	Ft	76.20	In meters
Friction Loss =	3.34	in meters		
	10.94	in Ft		
	4.74	In Psi		
	0.33	In Bar		

Table 4. Shows the friction loss calculation for main pipe for system designing of micro irrigation.

Friction Loss Calculation for Main Pipe

Block Numbers		1
Design Parameters	**UOM**	**Values**
Number of trees per pumping source.	Number	303
Main Pipe ID	Inches	1 1/2
Maximum length of Main Pipe	Feet	850
Required flow rate	GPM	27.49
Pressure loss in the Main Pipes	Feet	18.79

Friction Loss Calculation

C	215			
D =<3"	1 1/2	Inches	0.04	In meters
Q	27.49	GPM	2.08E-03	In m^3/Sec
L	850	Ft	259.08	In meters
Friction Loss =	5.73	in meters		
	18.79	in Ft		
	8.13	In Psi		
	0.56	In Bar		

and laterals before it is discharged into the field through point source emitters. The fertilizers and other chemicals are usually injected into system up stream of filters. Trickle irrigation is very suitable for fruit trees and vine crops. It is adaptable to any farmable slope and soils texture.

The uniformity of water application from an irrigation system is affected both by the water pressure distribution in the pipe network and by the hydraulic properties of the emitters used. The emitter hydraulic properties include the effects of emitter design, water quality, water temperature, and other factors on

Table 5. The friction loss calculation of hydrozone for system designing of micro irrigation.

Friction Loss Calculation for Hydrozones		
Block Number		1
Hydrozone Number		1
Design Parameters	**UOM**	**Values**
Number of trees in the hydrozone	Number	35
Number of laterals in a hydrozone	Number	7
Lateral Pipe ID	Inches	1/2
Number of row(s) to be served by one lateral	Number	One Row
Maximum length of Lateral	Feet	164
Number of trees per Row.	Number	5
Number of trees to be served by one lateral.	Number	5
Required flow rate per tree keeping in view PWR	GPM	0.79
Required flow rate for the Hydrozone keeping in view PWR	GPM	27.49
Required flow rate per lateral (Maximum length) keeping in view PWR	GPM	3.93
Pressure loss in the hydrozone	Feet	43.91

Friction Loss Calculation				
C	215			
D	1/2	Inches	0.02	In meters
Q	3.93	GPM	2.98E-04	In m^3/Sec
L	164	Ft	49.99	In meters
Friction Loss =			1.91	in meters
			6.27	in Ft
			2.72	In Psi
			0.19	In Bar

emitter flow rate. Factors such as emitter plugging and wear of emitter components will affect water distribution as emitter's age.

Evaluation is the analysis of any irrigation system based on measurements taken in the field under the condition and practices normally used. The field evaluation of drip irrigation system is important for several conditions:

1. to determine whether or not designed emitter discharge uniformity specification are being met for the system and its sub units:
2. to decide whether the system can be operated efficiently and could be improved:
3. to determine what equipment may need to be repaired, replaced or improved.

This study was conducted by Plant Introduction Centre of SARC, PARC, Karachi at the growers field of Gadap area.

The main objectives of this study were:

- Design of Drip irrigation to measure the emitter discharges at different hydro- zones of the drip irrigation system
- To evaluate the discharge uniformity of drip irrigation in the field.
- To find emission uniformity of the installed drip irrigation system.

METHODOLOGY

The study was conducted at Abdul Wahid farm at Gadap in Karachi. The general characteristics of the area showed that the soil was silty sand and comes under the coastal area. The rainfall is very rare throughout the year. The area is being irrigated by the runoff collected from the catchment of Gadap which is stored in Thado Dam. Mostly the crop areChicku and Bare giving fruits from May to July. The area of the farm under the study was 3.65 hect (9 acres).

The climate in this area is mild and humid, and the rainfall in this zone is the highest in Sindh (180-250 mm/year) but is still not a major contributing factor to agriculture production. Zone C is the coastal zone of the province with complex cropping system. The main crops are rice and sugarcane in Kharif, which are followed by wheat and vegetables in perennial areas whereas sunflower dominates the dubari areas in non-perennial canal command area. The main vegetables grown are onion and tomato. Onion is also grown as intercrop in sugarcane. The zone is peculiar in production of banana, chiku, papaya and coconut fruits. The palm oil plantation is also introduced in this zone and it is successfully grown. Soils of Sindh vary in texture from light sandy soils (21%) to moderately fine and fine clayey soils (40%). Medium textured soils i.e. loams of different composition constitute 39% of the total. The soils are calcareous to varying degrees because of presence of free calcium carbonate. Soil pH generally ranges from 7.5 to 8.5. Higher pH values are obtained for sodic soils with predominance of sodium in relation to calcium and magnesium ions.

(source: Sindh Agriculture Extension and Adaptive Research Report (1994))

The fruit trees were planted at 40’×40’, 35’×35’, and 25’×25’. The fruit trees were irrigated by newly installed drip irrigation.

Table 6. The basic farm data, design consideration, pressure loss information, flow requirement, pumping system recommendation of system designing of micro irrigation.

BASIC FARM DATA		
Farmer Name	AkhtarBagh	
Location	Gadap	
Crop Type	Chicku	
Area of the farm	9.00	Acres
Cropping Pattern	35x35	Feet x Feet
Total Number of trees	303	Number
Number of trees per acre	34	Number
Current Age of the tree	13	Year(s)
Current Canopy Area (Diameter)	8	Sqt. Feet
Current Peak Water Requirement	5	Gallons/Day
Average Water Requirement	4	Gallons/Day
Tree Maturity Age	17	Year(s)
Mature Tree Canopy Area (Diameter)	21	Sqt. Feet
Peak Water Requirement at Maturity	38	Gallons/Day
Average Water Requirement at Maturity	26	Gallons/Day
DESIGN CONSIDERATION		
Variables	**Values**	
System running time keeping in view Peak Water Requirement (PWR) for a mature tree per Hydrozone	0.8	Hours
Total number of blocks.	1	Number
Number of trees in a block.	303	Number
Total system running time for a block	8	Hours
Water storage capacity required per block keeping in view PWR.	34,275	Gallons
Number of Hydrozones in a block.	10	Number
PRESSURE LOSS INFORMATION		
Pressure loss in Hydrozone – 1	43.91	Feet
Pressure loss in Hydrozone – 2	43.91	Feet
Pressure loss in Hydrozone – 3	43.91	Feet
Pressure loss in Hydrozone – 4	43.91	Feet
Pressure loss in Hydrozone – 5	45.52	Feet
Pressure loss in Hydrozone – 6	30.60	Feet
Pressure loss in Hydrozone – 7	30.60	Feet
Pressure loss in Hydrozone – 8	11.30	Feet
Pressure loss in Hydrozone – 9	36.72	Feet
Pressure loss in Hydrozone – 10	37.64	Feet
Pressure loss in Hydrozone – 11	0.00	Feet
Pressure loss in Hydrozone – 12	0.00	Feet
Total Pressure loss in Hydrozones	45.52	Feet

The detailed layout of the system was based on the mature tree canopy of the Chiku trees planted on the farm.

Components of the Drip Irrigation System

The drip irrigation system consists of the water source, motor pump, main line; sub main line, lateral line, micro tube and pressure gauge. Generally a permanent water source is required for operating a drip or sprinkler irrigation system, which should contain the required volume of water for two to three days. Hence the system requirement is fulfilled through Thado Dam as mentioned. The 3hp centrifugal pump has been installed at the water source, which support a 180 feet head that is totally supplying a discharge capacity of 85 gallons per minute. The Hydrozone consists of a submain line, which is connected to main line through valve. The lateral lines are connected to the sub main line and the emitters are on lateral lines of each hydrozone The main line of (1 ½”) has been installed at the farm. The sub main line of (1 1/4”) has been installed with sub main valves that regulate water from the main line to sub main line. The lateral line of (1/2”) was installed which transform water from the sub main line to plant. The micro tube of 5mm has been connected to each lateral which has been further divided into two micro tubes of 3mm that takes water to the plant root zone. Pressure gauge has been fitted on

Figure 6. plot showing main, submain, lateral, valve and emitters

Figure 7. joining of main line during installation of drip

Figure 8. Showing flow in microtubes

the delivery section of the pump for recording water pressure in the system.

Design procedure of a Drip Irrigation System

The drip irrigation is very efficient method of supplying water to plants. This is relatively new method of more precise placement of water, and even through it takes more knowledge to operate the equipment, it means more food and fiber for human survival. As the world population continues to increase, this means that water will have to be used the most efficient way known to feed the peoples,

The field application of micro irrigation system requires the following procedure to be follows:

i. Site Survey

It includes calculation of the total area of the farm, number of trees, slop, plant to plant and row to row distance (table 15).

ii. Lay out

A layout is drawing on the graph paper to locate the field position and number of trees.

iii. Auto CAD lay out

It is the computerized layout drawn in a computer software auto cad. Which include all the details of map number of total trees, plant-to-plant and row-to-row distance. The whole field can be divide in to numbers of hydrozone .the total length of main submain and later, etc can also be calculated.

iv. Designing File

This specialized software calculates the friction losses in the pipelines by using Hazen William equation. The friction loss equation for the pipe used in the study is as follow

f = 10.666 C^-1.85 x D^-4.87 x Q^1.85 x L

Where f is the friction loss in the pipes, C is the coefficient of the material, D is the diameter of the pipe, L is the length of the pipe and Q is capacity of discharge by the motor pump. For these calculations basic farm data which include the farmer's name, location of the farm its area, cropping pattern, total number of trees, number of trees per acre, current age of the tree, current canopy diameter. These factors calculate current peak and average water requirement. When mature tree age and its canopy diameter is entered as input data as giving rise to relative peak and average water requirement respectively. The design process input data file requires system running time (hours) while keeping in view the peak water requirement for a

Table 7. Variation in discharge of emitters in different hydrozones.

S.NO	Hydrozone	Distance (feet) of Hydrozone on Main line	Position of Emitterv	Discharge (Gph)	Distance from Valve (feet)	R^2
1	1	858.3	L1 Head	74.11	103	Y = -0.5148x + 70.679
			L3 Head	64.36	20	R^2 = 0.0385
			L5 Head	62.73	73	
			L1 Mid	75.23	184	
			L3 Mid	70.74	100	
			L5 Mid	59.44	153	
			L1 Tail	76.61	224	
			L3 Tail	72.22	140	
			L5 Tail	57.50	193	
2	2	1065. 7	L1 Head	77.66	92. 7	
			L3 Head	76.69	37. 1	y = -2.0052x + 80.661
			L5 Head	69.50	66.7	R2 = 0.4465
			L1 Mid	78.51	162. 7	
			L3 Mid	70.61	107.1	
			L5 Mid	63.33	136. 7	
			L1 Tail	79.30	232.7	
			L3 Tail	64.47	177. 1	
			L5 Tail	55.65	206. 7	
3	3	1195.2	L1 Head	67.83	61. 3	y = -1.5808x + 68.314
			L3 Head	60.44	42. 2	R2 = 0.5266
			L5 Head	71.70	92. 9	
			L1 Mid	57.25	131. 3	
			L3 Mid	59.49	112.2	
			L5 Mid	60.35	162. 9	
			L1 Tail	54.69	201.3	
			L3 Tail	59.09	182. 2	
			L5 Tail	52.86	232.9	
4	4	886.7	L1 Head	70.23	132. 5	y = -0.9244x + 69.181
			L3 Head	66.52	52. 7	R2 = 0.1203
			L5 Head	63.33	45	
			L1 Mid	63.79	212. 5	
			L3 Mid	71.24	132. 7	
			L5 Mid	58.26	125	
			L1 Tail	58.61	292. 5	
			L3 Tail	76.10	212.7	
			L5 Tail	52.93	205	
5	5	1049. 8	L1 Head	77.14	77. 3	y = -1.2992x + 80.45
			L3 Head	81.66	23.2	R2 = 0.6359
			L5 Head	75.81	83.4	
			L1 Mid	72.42	147. 3	
			L3 Mid	77.51	93.2	
			L5 Mid	73.29	153. 2	
			L1 Tail	67.77	217.3	
			L3 Tail	69.19	163. 2	
			L5 Tail	70.80	223. 2	
6	6	1221.5	L1 Head	76.47	86.7	Y = -4.0307x + 84.306
			L3 Head	89.40	18. 5	R^2 = 0.3933
			L5 Head	54.54	66. 7	
			L1 Mid	72.09	156. 7	
			L3 Mid	83.21	88.5	
			L5 Mid	57.80	136. 7	
			L1 Tail	39.12	226.7	
			L3 Tail	41.73	158.5	
			L5 Tail	63.03	206. 7	

mature tree for a hydrozone, total number of blocks and number of trees in each block, number of days to store water for irrigation and number of Hydrozones in a block. This data give rise to total system running time for a block and its water storage capacity.

Water requirement input data file specify the location, Eto (reference crop evapotranspiration) and Kc values for the concerned location, current plant and mature plant areas in squire feet which gives rise to crop evapotranspiration (Etc) and suggested emitting discharge rate (gpm).the data of Eto and Kc can be browsed from the existing files or can be put in the current file for all months of the year with their average and peak separately.

Friction loss calculation file for submain pipes include the numbers of block and hydrozone, submain pipe internal diameter (inches) and maximum length of sub main pipe (feet) as designing parameters which give rises to required flow rate (gpm) and pressure loss in the sub main pipes (feet). Friction loss calculation file for main pipes include the numbers of block and number of trees per pumping source and main pipe diameter with their maximum length give rise to required flow rate and pressure loss in the main pipe.

Friction loss calculation file for a hydro zone in a given block need the design parameters of tree and laterals, number of rows to be served by each lateral and its length, and trees per row produce flow rate per tree and in each hydro zone and lateral with their pressure losses. The irrigation scheduling for the whole year of plant needs for a given duration is reproduced.

Data Collection

The system has been designed and installed by Plant introduction centre, SARC, PARC, Karachi. The data was collected at the head, middle and tail of the alternate laterals in the command of each sub-main. The electric motor pump was continuously in operation when the valves of a single hydro-zone was open out of the total hydro-zone that is only one hydrozone was opened at a time. The graduated cylinder and stop watch was used to take the volume per unit time. Similar

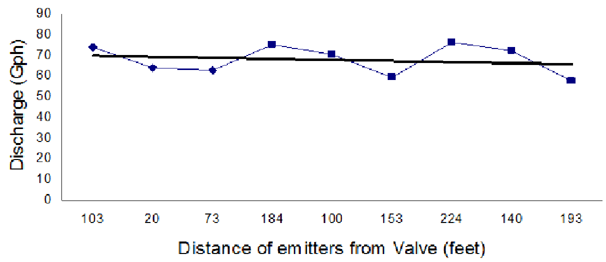

Figure 9. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 1 on Head, Mid, Tail of Lateral L1, L3, L5

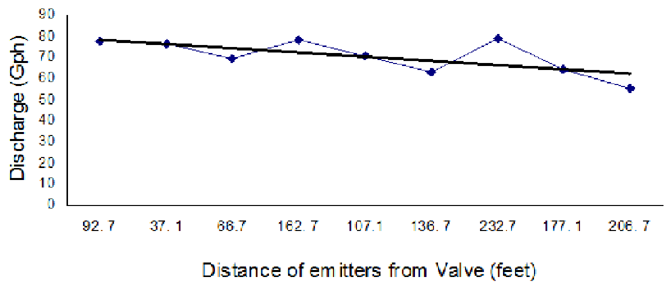

Figure 10. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 2 on Head, Mid, Tail of Lateral L1, L3, L5

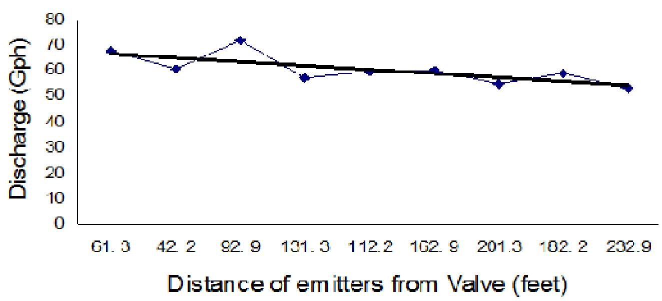

Figure 11. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 3 on Head, Mid, Tail of Lateral L1, L3, L5.

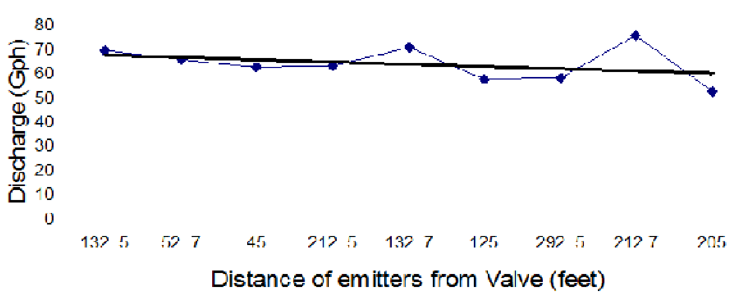

Figure 12. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 4 on Head, Mid, Tail of Lateral L1, L3, L5.

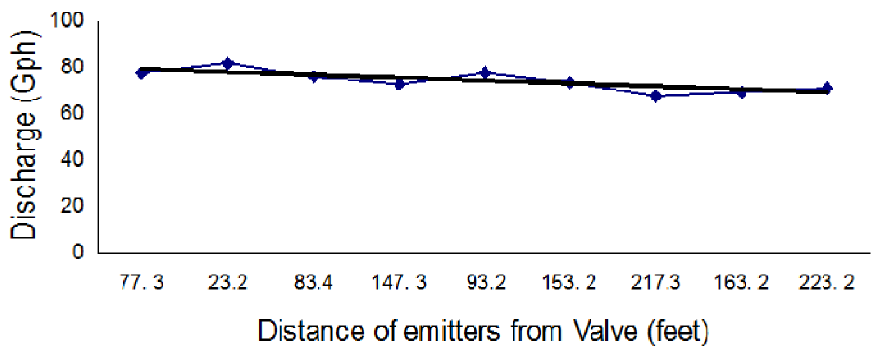

Figure 13. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 5 on Head, Mid, Tail of Lateral L1, L3, L5.

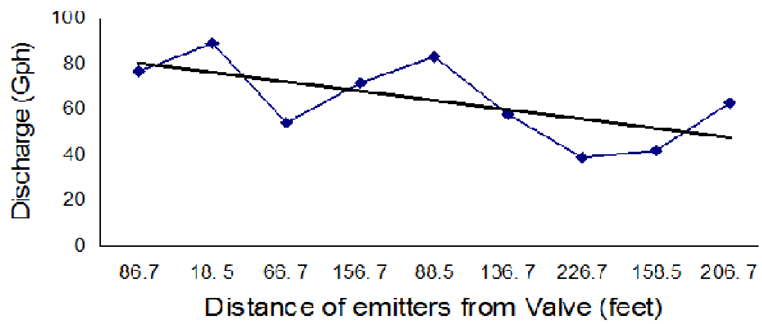

Figure 14. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 6 on Head, Mid, Tail of Lateral L1, L3, L5.

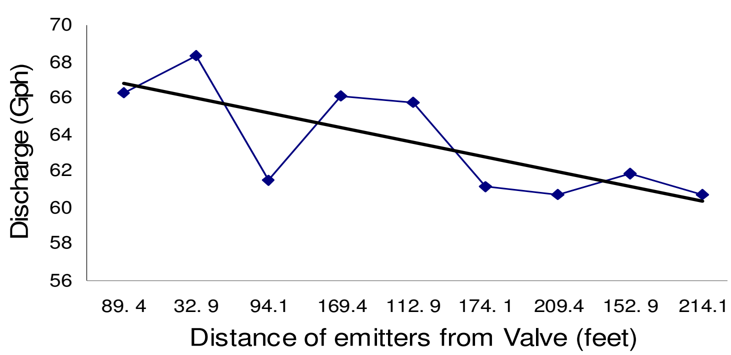

Figure 15. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 7 on Head, Mid, Tail of Lateral L1, L3, L5.

procedure was repeated at all the selected points for each hydro-zone. Totally 12 hydro-zones were selected and the readings were taken in the same at head, middle and tail of the laterals.

Discharge Uniformity of Drip Irrigation

Water flows through a pipe network, pressure drops due to friction losses in the pipes and fittings. Pressure changes also occur as water flows uphill (pressure loss) or downhill (pressure gain) in a pipe network. If a micro irrigation is poorly designed or improperly installed, pressure losses may be excessive because components are too small for design flow rates or slopes are too steep for the components selected. For these reasons, water application uniformity may be greatly affected by the design of the pipe network

The water application uniformity is a measure of how evenly the volumes of water are applied from each emitter. This uniformity can be determined by measuring emitter flow rates or the times required to fill a container of known volume. To measure emitter flow rates, graduated cylinder is used to

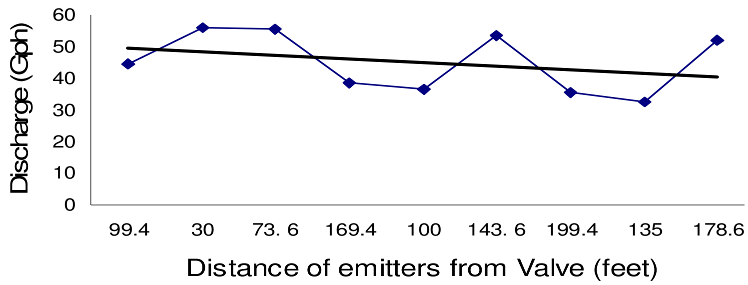

Figure 16. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 8 on Head, Mid, Tail of Lateral L1, L3, L5.

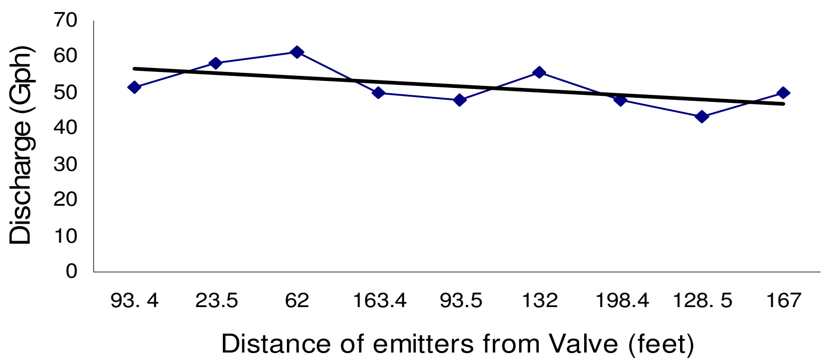

Figure 17. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 9 on Head, Mid, Tail of Lateral L1, L3, L5.

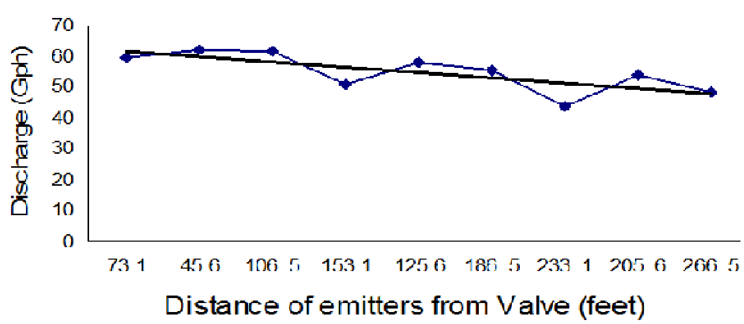

Figure 18. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 10 on Head, Mid, Tail of Lateral L1, L3, L5.

measure the volume collected for a given time with the help of stop watch. Measurements are taken at points located in each irrigated zone (Hydro Zones). The hydro zones are usually irrigated by a sub-main.

The hydraulic uniformity of drip irrigation system is estimated by measuring pressure at each irrigated zone. Pressure is measured to nearest emitter or hydrozone in pound per square inch (PSI). Pressure can easily be measured using a portable pressure gauge connected with pump.

Discharge Measurement

The discharge at each emitter was calculated as under,

$$Q = \frac{\text{volume of water collected in beaker (ml)}}{\text{Time (minutes)}}$$

Distribution Uniformity

The Distribution uniformity of the system can be determined by

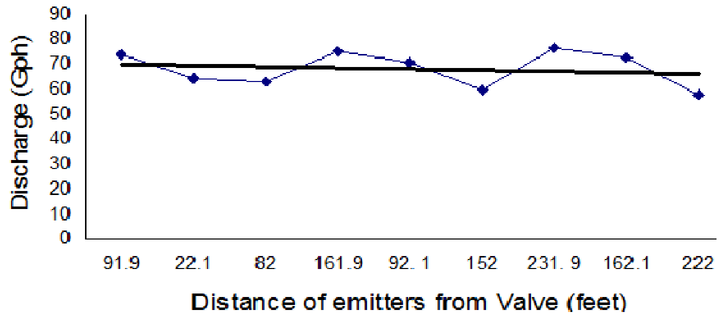

Figure 19. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 11 on Head, Mid, Tail of Lateral L1, L3, L5.

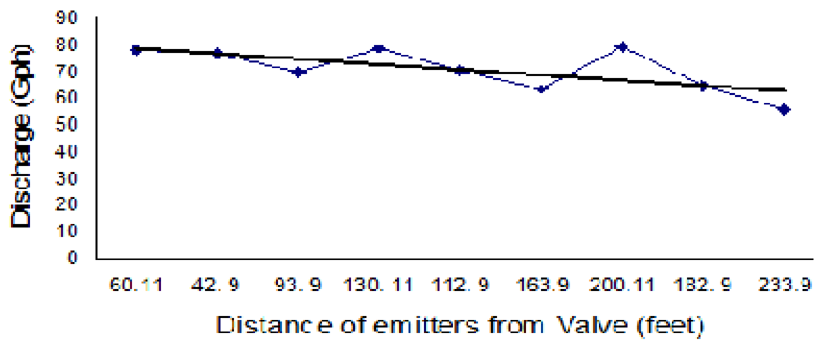

Figure 20. Discharge (Gph) Vs Distance (feet) of emitters from valve of Hydrozone 12 on Head, Mid, Tail of Lateral L1, L3, L5.

Table 8. Mean Hydrozones discharge and distance of emitters on laterals from submain line at constant pressure.

Hydro zones	**Pressure 12 (PSI)**		**Distance of hydrozone from source (ft)**
	Mean discharge (GPH)	**Mean distance of emitter (ft) on lateral from sub main**	
H1	68.11	96.6	1191.5
H2	70.63	80	1065.7
H3	60.41	87.5	1195.2
H4	64.56	101.1	886.7
H5	73.95	86.1	1049.8
H6	64.15	83.9	1221.5
H7	63.60	89.5	836.1
H8	44.91	81.6	1056.8
H9	51.57	81.67	1224.5
H10	55.12	102	822.9
H11	68.11	34	1049.2
H12	70.63	34	858.3
Mean	62.98	1038.19	79.83

the following formula;

Distribution uniformity = Average rate of discharge of the lowest quarter.

Average rate of discharge.

Emission Uniformity

The uniformity of emission describes how evenly the emitters of the drip irrigation system emit water over the field.

EU =100 (1 -1.27 / 1) Qmin / Qave

Table 9. The mean discharge of emitters in different Hydrozones

Distance	Discharge uniformity %
79'83"	97

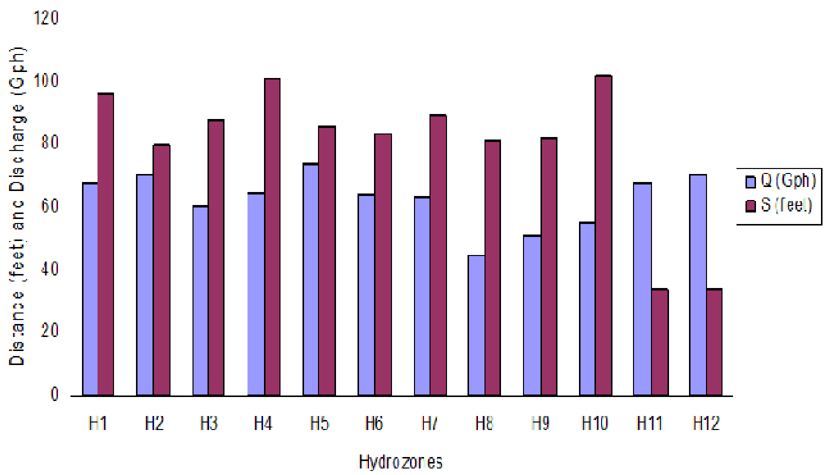

Figure 21. Showing mean discharge (Gph) and distance (feet) of

		Hydrozones											
Position of emitters	Emitters position on lateral	HZ1	HZ2	HZ3	HZ4	HZ5	HZ6	HZ7	HZ8	HZ9	HZ10	HZ11	HZ12
Head	L1	74.1	77.7	67.8	70.2	77.1	76.5	66.3	44.6	51.6	60.03	74.11	77.66
	L3	64.4	76.7	60.4	66.5	81.7	89.4	68.3	55.8	58.3	62.39	64.36	76.69
	L5	62.7	69.5	71.7	63.3	75.8	54.5	61.5	55.6	61.0	61.85	62.73	69.50
Middle	L1	75.2	78.5	57.3	63.8	72.4	72.1	66.1	38.3	49.7	51.29	75.23	78.51
	L3	70.7	70.6	59.5	71.2	77.5	83.2	65.8	36.3	48.0	58.26	70.74	70.61
	L5	59.4	63.3	60.3	58.3	73.3	57.8	61.1	53.5	55.8	55.88	59.44	63.33
Tail	L1	76.6	79.3	54.7	58.6	67.8	39.1	60.7	35.7	47.9	43.83	76.61	79.30
	L3	72.2	64.5	59.1	76.1	69.2	41.7	61.9	32.4	43.4	54.05	72.22	64.47
	L5	57.5	55.6	52.9	52.9	70.8	63.0	60.7	52.0	49.8	48.50	57.50	55.65
	SD	7.2	8.2	6.0	7.3	4.5	17.6	3.0	9.5	5.6	6.3	7.2	8.2
	Mean	68.1	70.6	60.4	64.6	74.0	64.2	63.6	44.9	51.7	55.1	68.1	70.6
	Cv	0.11	0.12	0.10	0.11	0.06	0.27	0.05	0.21	0.11	0.11	0.11	0.12
	EU	73.11	67.08	76.53	70.17	84.65	39.73	89.83	52.83	72.28	67.93	73.11	67.14
	ASAE Standard	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	90.00	91.00	92.00	93.00
	Good	-	-	-	-	-	-	✓	-	-	-	-	-
	Average	-	-	-	-	✓	-	-	-	-	-	-	-
	Marginal	✓	✓	✓	✓	-	-	-	-	✓	✓	✓	✓
	Unacceptable	-	-	-	-	-	✓	-	✓	-	-	-	-

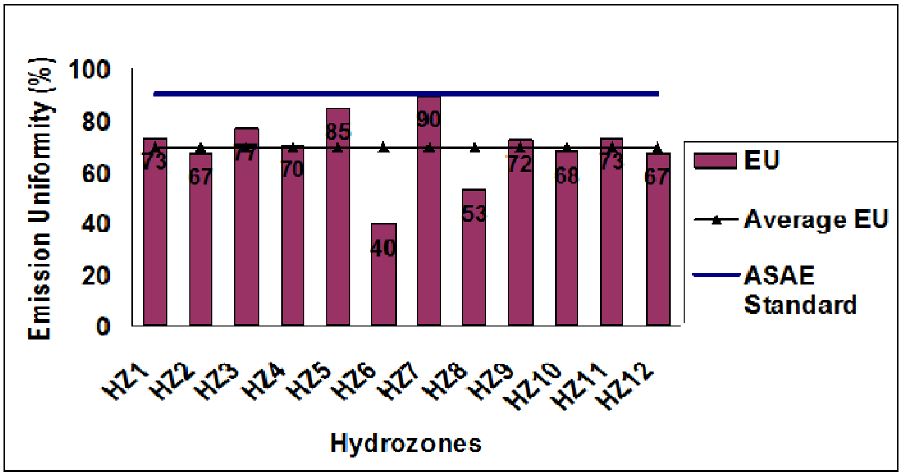

Figure 22. Emission uniformity, average emission uniformity and ASAE standard of emitters of 12 Hydrozones on Head, Mid, Tail of Lateral L1, L3 and L5

Coefficient of Variation

It is the ratio of standard deviation and arithmetic mean and is a fraction without units. It is use to compare the variation in two or more data sets.

Cv = standard deviation / mean

Criteria based on CV

Good	=	0.05
Average =	0.05-0.10	
Marginal =	0.10-0.15	
Unacceptable	>	0.15

RESULTS AND DISCUSSIONS

The Schematic Layout of the trickle irrigation system studied during the period June- September 2012, at Gadap, Karachi is shown in Figure 5. The system consists of 12 Hydrozones each hydrozone has 5-6 laterals with length range from 151 to 190 feet. The distance between row to row and plant to plant in Hydrozones 1, 4, 7, 8 is 40 feet and in Hydrozones 2, 3, 5, 6, 9, 10, 11, 12 is 35feet.

Discharges of Emitters

Relationship between discharge and emitters position on lateral were developed for each hydrozone and plotted (Figure 9 to 21).

In Hydrozone one the cause of decreased in discharge at the right of hydrozone one spread the pressure from the main due to closed spacing of lateral (L5) in relation to L4. The uniform increased in discharge all along lateral L1 developed pressure at its end, which gave rise to greatest discharge at its end. The similar phenomenon at the middle of hydrozone in L3 did the same. But a little bit sudden increased at the start upon the middle was due to the closeness of the valve to the lateral.

In Hydrozone two the cause of increased in discharge at the left of Hydrozone on L1 was due to the proper functioning of all the nozzles and increased in distance between emitter because Imli trees hade greater distance between trees then Chicku trees. The decreased of discharge in the middle of Hydrozone two on L3 was due to the closed spacing of Chicku trees and partially clogging of emitters. The same was the case at the right of Hydrozone on L5, which also have decreased in discharge.

In the Hydrozone three same phenomenons was observed the discharge was decreased gradually from head to tail on L1 to L5 due to increased in distance of main line. The discharge was decreased with increasing distance of laterals that increase frictional losses.

In Hydrozone four the cause of the decreased of the discharge at the right of Hydrozone four spread the pressure from the main due to closed spacing of lateral (L5) in relation to L4. The uniform increased in discharge all along lateral (L3) developed pressure at its end, which gave rise to the discharge at its end. But a little bit sudden increased in discharge was due to closeness of the valve to the lateral. The similar phenomenon at the left L1 of Hydrozone and L5 did the same.

In Hydrozone five the cause of decreased of discharge at the left of Hydrozone on L1 was due to slop and decreased in distance between emitters for Chicku trees that hade short distance between trees in relation to imli trees. The decreased of discharge in the middle of Hydrozone two on L3 was due to the closed spacing of Chicku trees and partially clogging of emitters. The same was the case at the right of Hydrozone on L5, which also hade decreased in discharge.

The Hydrozone six in which cause of decreased of discharge at the left of hydrozone on first lateral (L1) and in the middle on latesl (L3) was due to under and over sizing in standard of some emitters and elevation difference. But at the right of hydrozone on lateral (L5) was due to the proper sizing of emitters and less elevation difference

In Hydrozone seven the cause of decreased of the discharge at the right of Hydrozone spread the pressure from the main due to closed spacing of lateral (L5) in relation to L4. The decreased of discharge in the midle of Hydrozone seven on L3 and head on lateral L1 was due to partially clogging of emitters.

In the hydrozone eight same phenomenon was observed the discharge was decreased on each lateral gradually from head to tail on L 1 to L 5 due to increased in number of emitters and leakage of the end plugs.

The hydreozone nine in which cause of decreased of discharge at left of hydrozone on lateral L1 was due to increased in distance of lateral from the valve resulted in pressure losses. In the middle on lateral L3 of the hydrozone that hade a little decreased in discharge from head to tail was due to closed spacing of lateral (L3). The same was the phenomenon at the right of hydrozone on lateral (L5).

In Hydrozone ten the cause of decreased of discharge at the left of hydrozone on lateral (L1) was due to elevation difference. In the middle of hydrozone on lateral (L3) that hade a little decreased in discharge from head to tail was due to closed spacing of lateral (L3) to the valve. The same was the phenomenon at the right of hydrozone on lateral (L5), which hade the little variation in discharge due to little variation in elevation.

In Hydrozone eleven the cause of increased of discharge at the left of hydrozone on lateral (L1) was due to proper functioning of the emitters. In the middle of hydrozone on lateral (L3) that hade a sudden increased in discharge at the start upto the middle was due to the closeness of the valve. The cause of decreased of discharge at the right of hydrozone was due to leakage of end plugs.

In Hydrozone twelve the cause of increased of discharge at the left of hydrozone on lateral (L1) was due to uniform size and distance between the emitters. In the middle of hydrozone on lateral (L3) that hade a decreased in discharge due to partially clogging of the emitters. The lateral (L5) in hydrozone that hade little variation in discharge was due to less elevation difference.

Uniformity of Different Hydrozones:

Discharge uniformity observed under different distances of hydrozones from water source on main line basis. Results show that discharge uniformity decreased by decreasing the distances among emitters and some other factors that are under and over sizing in standard of some emitters, distance among emitters, clogging of the emitters, length of later line. The discharge uniformity was 97% at 79.8 (feet) of distance among emitters at Head, Mid, and Tail on lateral line. While the distance of hydro zones were varying on main line basis.

Coefficient of Variation and Emission uniformity

On the base of Coefficient of Variation all the twelve hydrozones were categorized as good, Average, Marginal and Unacceptable. out of these Hydrozone 7 was performing good, Hydrozone 5 was average, Hydrozone 1,2,3,4,9,10,11,12 were performing marginal and Hydrozone 6 and 8 were unacceptable. The emission uniformity ranged from 52.83 to 84.65% with over all average of 69.53%

CONCLUSIONS AND RECOMMENDATIONS

The above study can be a useful tool for further studies. The discharge of emitters at different distances , pressure was kept constant. In order to arrive at proper conclusions, full evaluation of the system is necessary.

High value of average discharge was obtained at head and low values of discharge were found at tail of individual laterals under different distances among emitters and constant pressure.

In the different hydrozones the Emission uniformity ranged from 52.83 to 84.65% with over all average of 69.53%, which should be 90% for better performance as per ASAE criteria.

In general, based on the coefficient of variation 84 % of the emitter discharges were in the acceptable range while the emission uniformity for different distances of hydrozones is 97% at average distance of 79.8 feet.

Recommendations

1. Clogging was observed in emitters therefore more filtering devices are needed to reduce the clogging problem.
2. Leakage from laterals-mainline, emitter-lateral joints and end plugs were observed, which may cause variations in pressures and discharges of emitter. That can be reduced through fixing the joints.
3. Slope of the laterals should be uniform for each lateral and water meters should be installed into mainline..
4. There is variation in discharges of the emitter and needs improvement by installing pressure compensating emitter devices or each hydro-zones should be properly designed

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