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Comparison of Conventional and drip irrigation system on productivity, saving and cost consumption of water. (Case study)

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Abstract: Cotton and Banana are one of the major cash crops of Pakistan. Most of the farmers in Sindh use conventional irrigation system (furrow or flood irrigation) for the agriculture purpose, which causes water losses in the form of evaporation and runoff. Excess of water produces water logging which spoil soil and decrease crop yield. This study conducted to analyze the water losses during irrigation because Sindh Province is counted in the arid zone. This study was carried out at Talpur's Farm (District Jamshoro) and Kernal's Farm (District Tando Mohammad Khan). In developing countries, the most important factor is to control and obtain maximum yield with minimum expenses. According to the obtained results 34.25 maunds per acre yield of cotton was obtained by saving maximum water and 29.2 maunds per acre on the furrow system as per market. In terms of water consumption, the furrow irrigation system consumes about 60% to 70% more than the drip irrigation system. The yield of the banana crop was counted in terms of fingers and one crop contained minimum 4 fingers. In the drip system 430 crops were planted in one acre, so 430 crops contain 1720 fingers and 400 crops per acre in furrow irrigation that contain 1600 fingers. In perspective of water consumption, the furrow system consumes 55% to 65% more water than drip system. The initial cost for the irrigation system is very important for the farmers. However, drip system incurred 33% more cost than the furrow system Therefore, to promote the drip irrigation system 60% of total cost is being provide by the World Bank to the farmer/owner for adoption of the system.

Keywords: *Conventional, Drip Irrigation; Productivity; Evaporation; Cost analysis;*

1. Introduction

Agriculture is one of the oldest occupations of our civilization. The agriculture sector is the backbone of the economy of Pakistan. It contributes approximately 19.5% to Pakistan's Gross Domestic Product (GDP) [1]. Pakistan among the list of the luckiest countries that have equally four seasons and annually monsoon winds. Pakistan has very low reserves for the storage of water, during the rainy season there is not a sufficient solution to store water. On the other hand, our agriculture consumes about 70% to 85% of water to obtain the fruits and crops [1]. It was very important to control the irrigation system, that is why this system was introduced in (1932) after, the construction of the Sukkur barrage on the Indus River. After the remarkable response of Sukkur barrage. The controlled irrigation system proved that it can significantly increase the yield of agricultural products. But on the other hand, continuous seepage from canal networks and infiltration in agricultural lands without adequate drainage provision had created the problems of a reduction of water from the canals and rivers [19] According, to the 2018-2019 economic survey of the Pakistan Ministry of Finance provided awareness about the economy of the year (2019) it announced that the growth of the agricultural sector has increased with 3.6% from 3.5%. Rice and sugarcane increased with 8.80% growth and 7.40% growth respectively. The Surface drip irrigation system (SDIS) is a modern technique which can be used in any climate condition, especially in high temperature areas the drip irrigation is the most suitable technique to reduce the evaporation rate [4,6,13]. Through this system, irrigation can be done with the optimum amount of water and minimum losses of water [4,9]. In the micro irrigation system, the drip system reduces the wastage of water in agriculture and provide properly water at the root zone of the crops while the irrigation is needed and where it is needed [3,4,18]. It is very easy to irrigate any kind of crop. This is a milestone for agriculture to save water, through the drip irrigation system, and achieve the significant yield of the crop [2,8,18].

2. Problem Statement

A high evaporation and percolation rate in a conventional irrigation system, that's why a huge amount of water has been wasted. In the conventional irrigation system, low efficiency of fertilizers due to leaching and runoff that's why fertilizer cannot perform efficiently. During irrigation on the field, some-times over wetting on the soil causes high weed infestation.

3. Aims and Objectives

The aim of this study is to minimize the wastage of water in the agriculture field in arid areas of Sindh. The following are the specific objectives:

1. To conduct Experiment on the crops of Banana and Cotton by the surface drip irrigation system (SDI).
2. To compare the wastage of water, the cost and yield between SDI and the traditional irrigation system (furrow).
3. On the basis of results awareness will be provided about Surface Drip irrigation system (SDI) to the local farmers.

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4. Study Area

Tando Mohammad Khan is 35 km away from Hyderabad in Sindh province, which is spread in the 1734 square kilo meter area with a population of 677,228 (2017 census). District Tando Mohammad Khan has 3 Taluka and 16 union councils. The second site Kotri area located in the South West in Sindh on the right bank of the Indus River Jamshoro has 1,986,284 population (2017 census) and 4 Taluka and 30 UCs spread about 11402 square kilo meters of a total area during the study conducting a research study on both sites, Village Umar Abbasi and the site area of Kotri.

5. Location of Study Area

The research study was carried out on 4 acres (1.61874 hectares) each on the study field, Village Mian Umar Abbasi at the kernel Muzafar's farm near Sindh Abadgar Sugar mill, UC Bulri Shah Karim, District Tando Mohammad Khan at Latitude 240 90'64.05" N Longitude 680 42'08.88" E

Figure.1. Village Mia Umar, Tando Mohammad Khan

Figure.2.Village Mia Umar, Tando Mohammad Khan

Figure.3. Talpur Farm Kotri

Figure.4. Talpur Farm Kotri

6. Preparation of Land for Furrow Irrigation System

First of all, in the field along the proposed line of furrow set out a straight line. This can be done by marking a chalk line or aligning the mould of bricks and also with the help of ranging poles. Marking the chalk lines is the oldest and most famous method. An experienced person required for the plough along the marked line, it is very necessary to make the line accurately because the width and height of the furrow depends on it. The ridger-drawback connected with the tractor to make four furrows at a time.

7. Preparation of Land for Drip Irrigation System

To prepare the land for the drip system, the same method is used as in the furrow irrigation system, but in this method, the addition of some new techniques are used. For drip irrigation, we required a water tank for storage of water, and the water pump to pump the water from a tank to the field, and a valve installed in the main line to control the water pressure after valve filters must be installed at the starting point of the system to prevent the coarser particles. In the drip system, the main pipe line of 4 inches was laid through the field from one side of the field and laterals 8 to 16 mm were connected with the main line in respect of crop alignment, and each crop contains individual emitter through an emitter crop can be irrigated. Every emitter set as per water requirement of the crop, at the end point of the lateral there is an end cap, it can be open in case of blockage.

Figure.5. Drip system

8. Sowing

8.1 Sowing Procedure of Cotton.

The seed of Cotton was sown in the month of April, 2019. The seed was sowed on top of the Furrow system. When ploughing of land was done in a furrow system, then the required quantity as per land was applied to the land for first irrigation of the cotton crop in a furrow system. As the seeds absorb water, and oxygen germination begins. The germination of the seed started within 5 days from sowing under a furrow irrigation system. Then a required amount of water is applied to the furrow system. First irrigation applied 20 to 25 days after sowing of the cotton crop. The measured quantity of water was applied on the field during irrigation.

8.2 Variety of Cotton

The variety of cotton cultivated at the study area was Bacillus Thuringiensis (BT).

8.4 Seeding rate

The cotton's variety on the field was seeded on 13th April 2019. A seeding rate of 5 kg per acre was used in the furrow field and 4 kg per acre for the drip field.

9. Sowing Procedure of Banana

Wider spacing is the best way to produce the best fruit, so it is important that the wider spacing achieve by the tall cultivar than the dwarf ones. Plant to plant and row to row the spacing of 4 X 4 ft corresponding to a plant population of 925 per acre is preferred to attain more per acre yield and good quality fruit. A pit size of 50 X 50 X 50 cm is recommended for planting banana suckers. The soil of the pit must be exposed to sun light and air to avoid soil-borne diseases. After planting within 10 to 15 days.

9.1 Variety of Banana

In the study area, the cultivated variety of bananas was Barsai.

9.2 Planting rate

The variety of banana was planted on 15th March 2019. A planting rate of 925 per acre was used in furrow irrigation same for the drip irrigation system.

10. Approximate Estimation Model

Water measurement is the most important factor for the irrigation system, it will acknowledge us that how much water consumes per acre. For this purpose, some parameters which are required like each duration of irrigation, motor engine horsepower, the diameter of a suction pipe, and the length of the pipe collected from their farmers which related to the model to measure the consumption of water in liters which can be converted to cubic meters [9]

$$Q = \frac{tx129594.1xBHP}{[l + (255.5998xBHP^2)/lxD^2}$$

Where;
Q = the volume of water in (liters)
t =total duration of irrigation in (hours)
l = length of pipe in (feet)
D = diameter of the suction pipe in (inches)
BHP = the engine power of the tube-well (Horse Powers)
This formula gave the extraction of water in liters which we converted to a cubic meter

11. Stopwatch Method

The stopwatch method is easy and the most accurate method to calculate the discharge of water which is used in irrigation purpose. Stop watch method is the technique through which we can measure the quantity of water of both system's discharge of water like convention irrigation and drip irrigation. The stopwatch method is commonly used in the drip irrigation system for the purpose of measuring the discharge of the water from the drip station.

12. Weather Data

On the daily basis data related to weather of the study area were collected. It includes temperature Tmax, Tmin, and Tdew, rainfall (R) sunshine (n), and velocity of wind (u2). The weather parameters of study area like rainfall are calculated directly and For the calculation of daily ETo, the weather data collected from Regional Agromet Center (RAMC).

13. Cotton Crop

13.1 *Physical and Chemical Properties of TMK Field*

The soil at the study area was sandy loam with medium class in texture. Crops evapotranspiration (ETc) differs from ETo, and the grass is totally different from the canopy properties and aerodynamics of the crops. Categorize field of crops from grass are included in the crop coefficient with reference to aspects. To multiplying ETo with Kc in the coefficient of crop approach for calculating evapotranspiration. The main difference in transpiration and evaporation between grass surface and study area crops may be divided into two coefficients which are Kcb and Ke (Kc = Kcb + Ke). While accuracy and availability of the crops were required these phenomena are followed for acquiring goals and getting accurate results. Evapotranspiration rate from the field can be directly calculated by the Energy balance method or mass transfer method.
Soil at the study area was sandy loam and class is medium in texture.

Table.1. Physical properties of Soil

Depth (cm)	Sand %	Silt %	Clay %	Bulk density (gm cm$^{3)}$
0-15	50.1	23.3	24.2	1.22
15-30	54.6	21.5	19.7	1.31
30-45	53.8	20.3	22.3	1.36
45-60	50.9	21.6	21.9	1.38

Table.2. Chemical properties of Soil

S. no.	Parameter	Value
1	PH	7.33
2	EC (dsm^{-1})	1.30
3	Available nitrogen%	1.37
4	Available phosphorus(ppm)	0.65
5	Available potassium(ppm)	0.70

Table.3. Sample of daily data collection and processing for cotton

S.NO	Date	Day of year	ETo mm	Zr mm	TAW mm	RAW mm	D,ri start mm	R	I	I/fw mm	Kcb	Ke	Kc	ETc mm	DP mm	D,ri end mm
1	10/05/2019	130	5.34	400	52	36	0	0	36	72	0.15	0.52	0.67	3.61	0	4
2	02/06/2019	153	6.6	400	52	36	0	0	38	76	0.15	0.53	0.68	4.53	2	5
3	14/06/2019	165	6.6	430	56	28	0	0	29	58	0.29	0.53	0.82	5.47	1	5
4	22/06/2019	173	6.6	470	61	30	0	0	34	68	0.48	0.58	1.06	7.06	2	7
5	29/06/2019	180	6.6	505	66	33	0	0	37	74	0.64	0.45	1.1	7.26	2	7
6	06/07/2019	187	5.46	540	70	35	0	0	37	74	0.81	0.38	1.2	6.56	2	7
7	17/07/2019	198	5.46	595	77	38	0	0	44	88	1.07	0.12	1.2	6.56	2	7
8	27/07/2019	208	5.46	600	78	39	0	0	46	92	1.1	0.1	1.2	6.56	2	7
9	04/08/2019	216	2.83	600	78	39	0	0	43	86	1.1	0.1	1.2	3.39	2	3
10	02/09/2019	245	3.08	600	78	39	0	0	41	82	1.1	0.1	1.2	3.69	2	4
11	14/09/2019	257	3.08	600	78	39	0	0	42	84	0.98	0.22	1.2	3.69	2	4
12	26/09/2019	269	3.08	600	78	39	0	0	41	82	0.8	0.4	1.2	3.69	2	4
13	13/10/2019	286	3.1	600	78	39	0	0	42	84	0.54	0.51	1.05	3.28	2	3

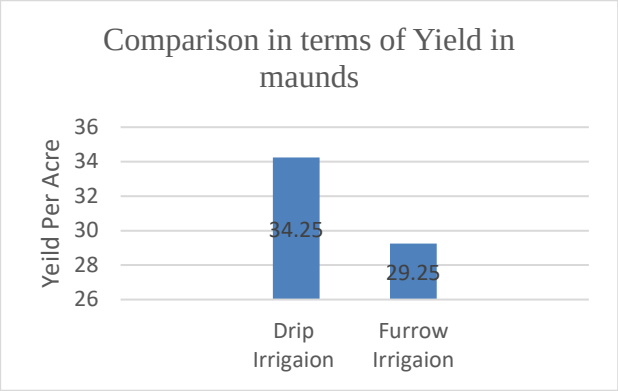

Figure.6. Comparison in terms of yield

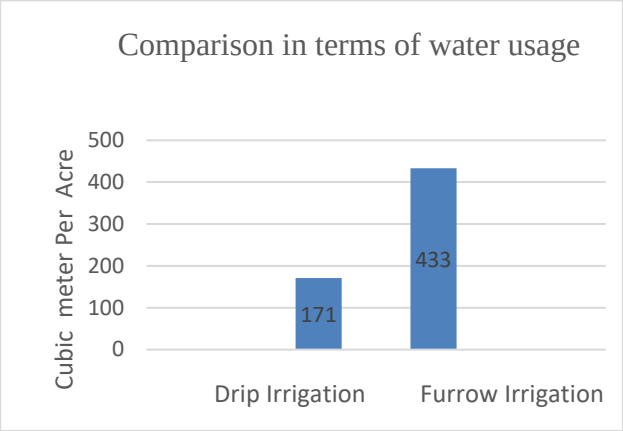

Figure.7. Comparison in terms of water usage

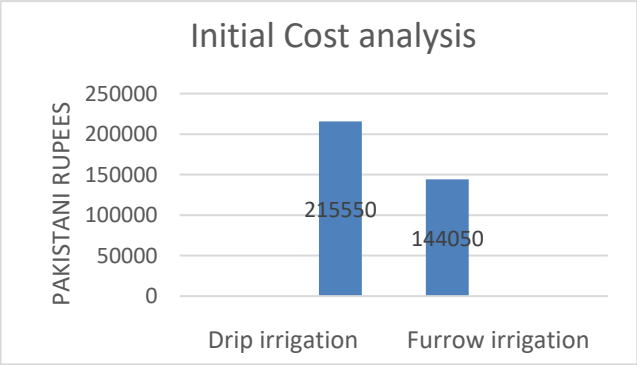

Figure.8. comparison in terms of cost

14. Irrigation Scheduling and Evapotranspiration of Crop

The seasonal calculated evapotranspiration of cotton at management drawn depletion MDD 55%, (ETc 55, and ETc 55 respectively) by Drip Irrigation and Furrow irrigation systems were collected 356, and 323 mm while actual ETca 55, were calculated 350 and 309 mm respectively by drip irrigation and furrow irrigation systems. The calculated evapotranspiration and actual evapotranspiration on daily basis in the experimental area are made up with respect to time in days, which are taken. The maximum actual ETca 55 estimated 5.81 mm day −1 at the field of the furrow irrigation

system and calculated 4.73 mm day−1 on the 103th and 78th day of sowing.

15. Banana Crop

Table.4. Physical properties of soil

Depth (cm)	Sand %	Silt %	Clay %	Bulk density (gm cm$^{3)}$
0-15	50.1	23.3	24.2	1.22
15-30	54.6	21.5	19.7	1.31
30-45	53.8	20.3	22.3	1.36
45-60	50.9	21.6	21.9	1.38

Table.5. Chemical properties of Soil

S. no.	Parameter	Value
1	pH	7.43
2	EC(dsm^{-1})	1.28
3	Available nitrogen%	1.53
4	Available phosphorus(ppm)	0.75
5	Available potassium(ppm)	0.73

Table.6. The sample of daily data collection and processing for Banana

S.NO	Date	Day of	ETo	Zr	TAW	RAW	D,ri start	R	I	I/fw	Kcb	Ke	``	ETc	DP	D,ri end
		year	mm	mm	mm	mm	mm			mm				mm	mm	mm
1	11/04/19	101	4.74	400	52	29	0	0	29	58	0.15	0.5	0.65	3.12	0	2
2	29/04/19	119	4.74	400	52	29	0	0	30	60	0.15	0.5	0.65	3.12	1	2
3	26/05/19	146	5.32	520	68	51	0	0	54	108	0.53	0.57	1.1	5.85	1	2
4	08/06/19	159	6.58	618	80	60	0	0	63	126	0.83	0.36	1.2	7.9	1	2
5	20/06/19	171	6.58	700	91	68	0	25	72	144	1.1	0.1	1.2	7.9	1	2
6	30/06/19	181	6.58	700	91	68	0	0	75	150	1.1	0.1	1.2	7.9	1	9
7	17/07/19	198	5.45	700	91	68	0	0	73	146	1.1	0.1	1.2	6.54	1	9
8	31/07/19	212	5.45	700	91	68	0	0	71	142	1.1	0.1	1.2	6.54	1	9

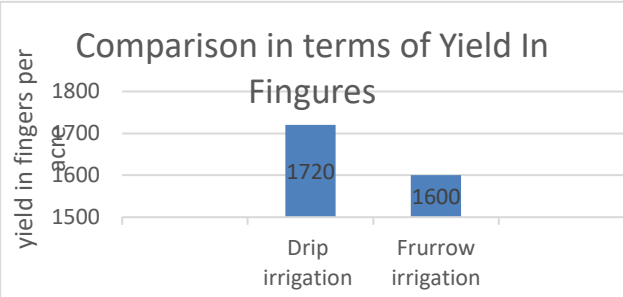

Figure.9. comparison in term of yield

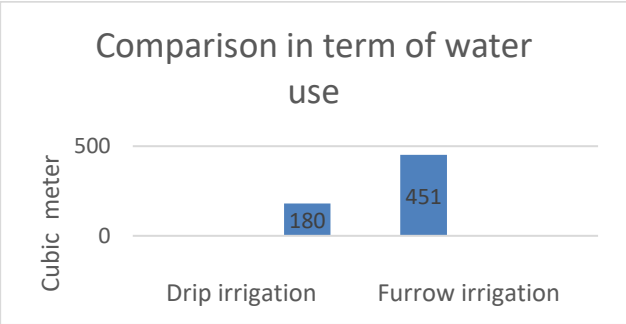

Figure.10. Comparison in terms of water usage

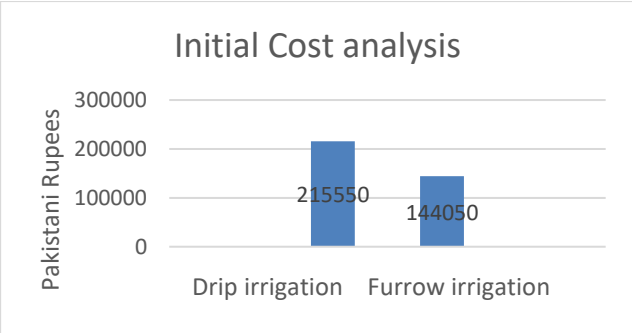

Figure.11. Comparison in terms of Cost

16. DISCUSSION

According to studies results as shown in table no 07, the Drip Irrigation System is more suitable to achieve maximum potential of Water Use Efficiency (WUE) in terms of comparison of drip irrigation and furrow irrigation system, drip irrigation is a more feasible technique. The study was conducted on Cotton and Banana crops. The yield of cotton on drip system, 34.25 maunds per acre and on the furrow system 29.2 maund per acre as per market. In terms of water consumption, the furrow irrigation system consumes about 60% to 70% more than drip irrigation system. The yield of

the banana crop was counted in terms of fingers and one crop contained minimum 4 fingers. In the drip system 430 crops were planted in one acre, that crops contain 1720 fingers and 400 crops in furrow irrigation that crops contain 1600 fingers. In terms of water consumption, furrow system consumes 55% to 65% more water than the drip. Initial cost for the irrigation system is very important for the farmers. The drip system is 33% more expensive then furrow Therefore, to promote the drip irrigation system 60% of total cost is being provided by World Bank to the farmer/owner for adoption of system.

Tabble.7. Profit comparison Cotton and Banana crops

	COTTON CROP		BANANA CROP	
Objectives	Drip System Per Acre	Conventional System Per Acre	Drip System Per Acre	Conventional System Per Acre
YIELD PRODUCTION (AS PER MARKIT)	34.25 maund	29.25 maund	1720 fingers	1600 fingers
WATER CONSUMPTION (M^3)	180	451	171	433
COAST ANALYSIS (PAK RS)	215550	144050	205850	165550

17. Conclusion

This dissertation was conducted to compare the drip and furrow irrigation system, for cotton and banana crops in terms of water, saving, and crop yielding with consideration of decreasing the expenditure in each crop. The following conclusions are revealed.

1. This study conclude that drip irrigation system is more feasible and nature friendly irrigation system.
2. The water saving in Drip irrigation system was calculated 77.57% greater than furrow irrigation system in Banana field.

Figure.12. Cotton Harvesting

Figure.13. Banana Harvesting

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