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Evaluation and Comparison of Tradition and Modern Methods of Irrigation on Maize Crop

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***Abstract* - Agriculture is entirely water dependent in the arid and semiarid regions of the world. In the water scarce country, like Pakistan we are facing water shortage due to less storage, more demand and inefficient use. So to overcome this problem the only option left with us is the efficient use of irrigation water with the theme of, when and where is required. The study was conducted on a farm in Tehsil Bhuwana, District Chiniot, (31.61°N, 72.86°E), on maize crop to evaluate the efficient and water saving technique by applying different methods on the basis of water productivity. RCBD statistical experimental design was used for the evaluation of this experiment. An area of more than one acre (90m*50m) in which three treatments, drip method, perforated pipe method and conventional method were applied. The results revealed that the average volume of water used in conventional, perforated pipe and drip irrigation was 7308.8 m^3/ha, 5662.96 m^3/ha and 3874.80 m^3/ha respectively. The average water productivity (WP) for conventional, drip and pipe system was 0.61kg/$m^{3,}$ 2.56 kg/m^3 and 0.98 kg/m^3 respectively. Thus concluded drip irrigation to be the best technique in respect of water saving and water productivity.**

***Keywords:**Water Productivity, Efficient, Irrigation, Perforated, Drip, Conventional*

I. INTRODUCTION

Pakistan economy is largely dependent on agriculture sector. Pakistan has abundant water resources but only a part of fresh water resources can be utilized due to limitations of geology, topography, physiology, quality and the present state of technology. Irrigation water is further decreasing because of rising demands in domestic and industrial uses [1].

Agriculture is facing two main challenges, first is the ever increasing population that causes increase in the demand and second one is the judicious and efficient use of limited available water resources. In 2050 there would be need 7000-12586 million km^3 of water to fulfill the food and fiber demand of 9.3 billion people. The only solution is to improve water productivity in agriculture [2].

The need of water is significantly increasing day by day, while the fresh water resources are becoming less. This is because of effect of climate change, drought and increasing water demands in terms of urbanization, irrigated surfaces and recreational projects [3].

Maize crop has significant position in the present cropping system of Pakistan. In Pakistan its grain production is at third position after wheat and rice. Maize is grown on an area of 1.02 million hectares in Pakistan. Its annual grain production is 2.96 million tons and average grain yield is 2893 kgha-1 [4].

The major agricultural use of water is for irrigation, which is affected by decreased supply. Therefore, improvement in crop water productivity (WP) in agricultural is of strategic importance. Both deficit irrigation (DI) and partial root-zone drying (PRD) are water-saving irrigation strategies [5].

Water stress is created due to deficit irrigation that effects the growth and development of maize plants. It is very important to evaluate yield drop due to applying deficit irrigation approaches [6] [7]. The result of water stress on maize plants has been shown to change with hybrid [8] [9] and by improving technological level it can be affected [10]. The result of water stress on maize hass been shown on canopy height [11] [12] [13] leaf area index, [14] [15] and root growth [16] [17]. The water stress also effect on the grain and biomass yield [18][19].

In Pakistan and all over the world many scientists and engineers have been working on the efficient irrigation systems which are most suitable and feasible for maize crop. The specified objectives of study are to evaluate the efficient and judicious irrigation system on maize crop and to determine the water productivity results by comparing three irrigation systems, i.e. Drip irrigation, Flood irrigation and Perforated pipe method.

II.MATERIAL AND METHOD

A. EXPERIMENTAL SITE

The experimental site was selected at Tehsil Bhuwana, Distt. Chiniot. The trial was conducted at Mianasgharali farm in a village named Mozasadev. Jani shah, (31.61°N, 72.86°E). The soil texture is clayey loam and irrigated by Jhang branch canal. The climate is arid to semi-arid with no distinct rainfall. June is warmest with an average temperature of 44 °C at noon. January is coldest with an average temperature of 4.8 °C at night.

B. Experimental procedure:

Maiz (Zea mays L., Varity 31P41) was cultivated in Asharali farm in March. The distance between rows was 0.96 m and 0.15m between plants. The experiment was laid out under randomized completely block design (RCBD). The total experimental area was 4500 m^2. It was divided into three blocks. Each block is further divided into three plots. Individual plot size has 10m*50m. So there were 9 total plots. There were three treatments. Each treatment is replicated three times. Three treatments selected for this experiment were as follows; one is conventional method, second is drip irrigation method and third is perforated pipe method.

C. Crop water requirement:

Crop water requirement is calculated by using CROPWAT model. It is computer based program developed by the Land and Water Development Division of FAO for irrigation planning and management [20]. Its basic functions include the crop water requirements, calculation of reference evapotranspiration along with the crop & irrigation scheme.

D. Measurement of discharge:

For flood irrigation, measurement of discharge was made by using 8*3 cut throat flume installed in the water course close to the experimental field. The water flow through the flume was calculated by Skogerboe [21]. Discharge measurement in Drip is done by noting the drip system running time, discharge is fixed by keeping pressure constant, usually at 1 bar or 2 bars. So in this way discharge can be measured, where as in perforated pipe discharge measurement is done by volumetric method.

E. Depth of Water Applied:

Water conservation was also being the main objective to study. As in deficit irrigation claimed that less amount of water is required for the crop growth than that full crop water requirement. For this purpose amount of water applied to each plot was calculated by using the equation [22].

$$Q*T = A*D \qquad (1)$$

Where,

Q = discharge from the tubewell m^3/sec
T = time in seconds
A = area of experimental unit in square meters
D = depth of water applied in meter

F. Yield measurement:

An area of 1 m^2 was harvested from each plot at random avoiding the border effects. The grains were threshed manually form the sample. The grains were dried at 70 degree centigrade for 24 hours in oven and then grain yield per unit area was determined.

G. Biomass harvesting:

Biomass harvested from 1 m^2 in the area. Separately collected all the treatments yield and then weight the plants with the cob and without cob. Samples were weighed in field to avoid moisture reduction to get the correct wet weight of samples and then oven dried for 48 hours at 70 ^oC and weighed again.

H. Water use efficiency:

Water use efficiency was calculated to note the effect of deficit irrigation. Water use efficiency was calculated after getting the total yield from every experiment unit. The relation of irrigation to crop yield is called irrigation production function. In this study crop water use efficiency was calculated from equation

$$WUE = GY/AW \qquad (2)$$

Where,
WUE = water use efficiency, kg ha^{-1} mm^{-1}
GY = Grain yield, Kg ha^{-1}
AIW = Applied irrigation water, mm

I. Statistical analysis of data:

The plant population, canopy cover, root length, yield, biomass and harvest index of maize, yield water use efficiency and biomass water use efficiency data were analyzed statistically using variance techniques following to the randomized complete block design (RCBD) by using computer software statistics 8.1 [23]. Treatments means were compared using LSD at 5% significance level.

III. RESULTS AND DISCUSSION

In order to evaluate and compare the efficiency of drip, perforated pipe and flood irrigation system, different methods are adopted and their results are shown below.

A. Grain Yield:

Grain yield of maize is the yield that we obtained after harvesting without plant material (corn stovel). It only refers to corn kernel. The grain yield of all the treatments was obtained at the end of experiment is shown in Table 1.

Table 1 Grain yield of all treatments (Tc, Td &Tp)

Plots	***Treatments***	***Grain yield(kg/ha)***	***Average Grain yield(kg/ha)***
2	T_C	4434.5	
4	T_C	4245.0	4340.2kg/ha
9	T_C	4341.3	
1	T_D	9979.8	
5	T_D	9468.0	9745.6kg/ha
7	T_D	9789.0	
3	T_P	5773	
6	T_P	4849	5548.3kg/ha
8	T_P	6023	

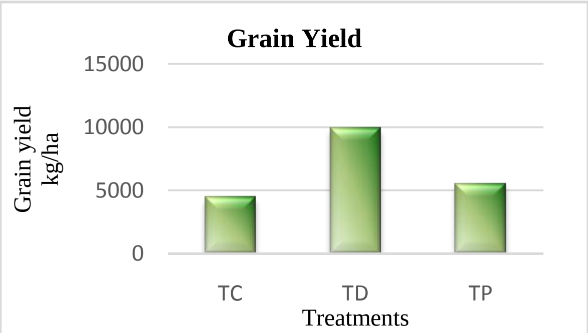

Fig. 1 Bar chart average grain yield vs. treatments

In Fig 1, a bar chart is illustrating the trend of grain yield in all treatments. The maximum peak of bar is attained in case of drip as it has highest average grain yield value. The lowest bar is attained in case of conventional method because it has the lowest value of average grain yield value.

B. Biomass Yield:

The biomass was found by measuring the weight of plants of all treatments (T_d, T_c and T_p). The average biomass yield that was obtained at the end of experiment is shown in Table 2. Fig 2 Illustrates clearly that in the biomass yield in drip treatment is significantly high whereas in perforated pipe treatment the biomass yield is minimum.

Table 2 Biomass yield of all treatments (Tc, Td&Tp)

Treatments	***Grain yield (kg/ha)***	***Biomass yield (kg/ha)***
T_C	4434.5	127549
T_C	4245.0	138878
T_C	4341.3	108437
T_D	9979.8	129651
T_D	9468	130784
T_D	9789	112765
T_P	5773	124237
T_P	4849	134579
T_P	6023	113832

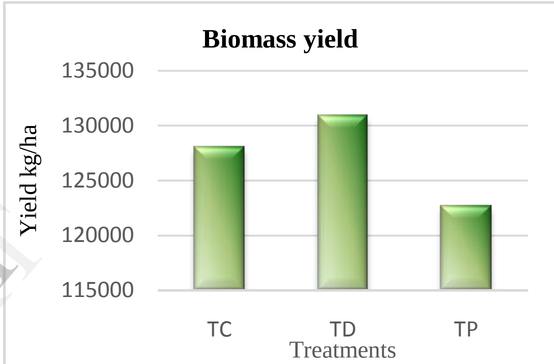

Fig. 2 Bar chart average Biomass yield vs. treatments

C. Volume of water used:

The measure of water archived in the soil at the start of a product developing seasons is measured. At that point the aggregate sum of water supplied to the plant by precipitation and watering system throughout the developing season is recorded. At long last, the measure of water saved in the soil at the closure of product developing season is measured. The difference between the starting soil water and end soil water, in addition to precipitation and watering system, is more or less equivalent to product water utilization. Fig 3 shows that minimum water is used in drip treatment, where as in conventional method maximum water is used as compare to drip and pipe method.

Table 3 volume of water applied considering the effective rainfall

Treatments	*Eff. Rainfall (in)*	*water applied(m)*	*Area (m^2)*	*vol. of water(m^3)*	*vol. of water(m^3/ha)*
T_C	1.1	0.70	500	350	7308.88
T_C	1.1	0.74	500	370	7308.88
T_C	1.1	0.76	500	380	7308.88
T_D	1.1	0.34	500	170	3874.80
T_D	1.1	0.36	500	180	3874.80
T_D	1.1	0.38	500	190	3874.80
T_P	1.1	0.57	500	285	5662.96
T_P	1.1	0.60	500	300	5662.96
T_P	1.1	0.62	500	310	5662.96

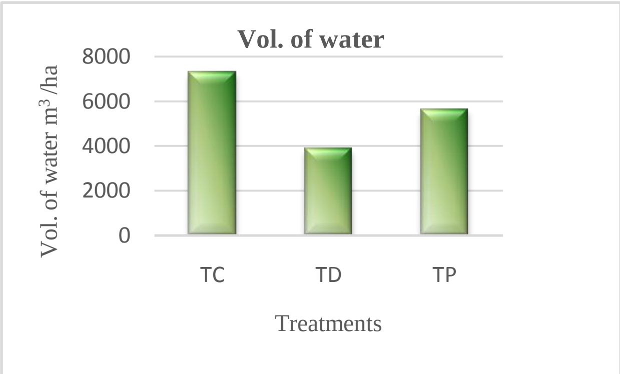

Fig. 3 volume of water used

D. Harvest Index:

Harvest index is defined as the pounds of grain divided by the total pounds of above ground biomass (stover plus grain). Harvest index = lbs of grain / (lbsstover + lbs grain) The calculations for determining harvest index are given below.

Table 4 Harvest Index table

Treatments	*Grain yield (kg/ha)*	*Biomass yield (kg/ha)*	*Harvest Index (%)*
T_C	4434.5	127549	3.48
T_C	4245	138878	3.06
T_C	4341.3	108437	4.00
T_D	9979.8	129651	7.70
T_D	9468	130784	7.24
T_D	9789	112765	8.68
T_P	5773	124237	4.65
T_P	4849	134579	3.60
T_P	6023	113832	5.29

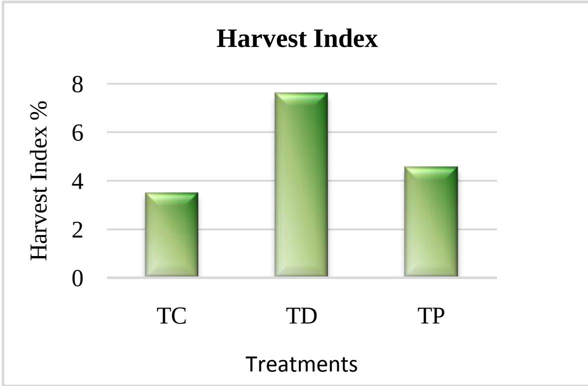

Fig. 4 Bar chart of Harvest index vs. treatments

Fig. 4 shows that harvest index is maximum in case of drip treatment and harvest index is minimum in case of conventional method.

E. Water Productivity:

Water productivity refers to the value of goods and services produced per unit of water consumed**.** Here, the term water profit is utilized only to signify the sum or quality of item over volume or worth of water exhausted or redirected.

Table 5 Water productivity for all the treatments

Treatments	*Grain yield (kg/ha)*	*vol. of water (m^3/ha)*	*water productivity (kg/m^3)*
T_C	4434.5	7308.88	0.62
T_C	4245	7308.88	0.61
T_C	4341.3	7308.88	0.59
T_D	9979.8	3874.80	2.70
T_D	9468	3874.80	2.42
T_D	9789	3874.80	2.55
T_P	5773	5662.96	0.98
T_P	4849	5662.96	0.87
T_P	6023	5662.96	1.08

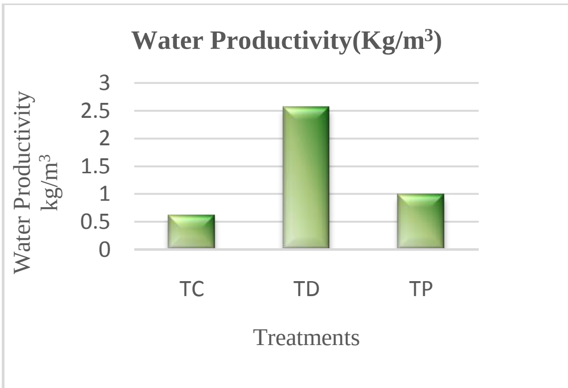

Fig. 5 Bar chart of Water productivity vs. treatments

Fig 5 showing that water productivity is maximum in case of drip irrigation method and water productivity is minimum in case of conventional method.

F. Irrigation efficiency:

It is the ratio between irrigation water actually utilized by growing crops and water diverted from a source (as a stream) in order to supply such irrigation water.

Table 6 Irrigation efficiency

Treat ments	***E_{to} (in)***	***Total depth(in)***	***Irrigation efficiency (%)***	***Average (%)***
T_C	14.63	28.78	50.86	
T_C	14.63	28.78	50.86	50.86
T_C	14.63	28.78	50.86	
T_D	14.63	15.26	95.93	
T_D	14.63	15.26	95.93	95.93
T_D	14.63	15.26	95.93	
T_P	14.63	22.30	65.64	
T_P	14.63	22.30	65.64	65.64
T_P	14.63	22.30	65.64	

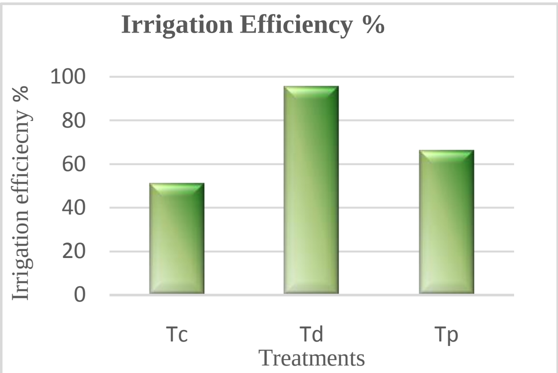

Fig 6 Bar chart of irrigation efficiency vs. treatments

Fig 6 shows that Irrigation efficiency of drip is maximum i.e. about 95.93%, irrigation efficiency of perforated pipe method is on 2nd i.e. 65.64% and the conventional method has least efficiency i.e. about 50.86%.

IV. CONCLUSIONS

From this study we concluded that drip irrigation is very useful technology for farmers. Water wastes a lot especially in conventional method. Less water is used in case of drip irrigation, if we compare total water used between drip irrigation and conventional irrigation then we come to know that 46.9 % water was saved in drip irrigation and 22.5 % in perforated pipe irrigation as compare to conventional method. Irrigation efficiency of drip is maximum i.e. about 95.87%. Water productivity was maximum in case of drip irrigation method. By adopting drip irrigation yield increased very much as compare to conventional and pipe method. So the farmers should adopt this technology and avoid conventional method of irrigation.

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