*J. Glob. Innov. Agric. Soc. Sci., 2017, 5(1): 32-38.*
*ISSN (Online): 2311-3839; ISSN (Print): 2312-5225*
*DOI: https://doi.org/10.22194/JGIASS/5.1.780*
*http://www.jgiass.com*

# MAIZE PRODUCTIVITY ANALYSIS UNDER DRIP IRRIGATION AND BED PLANTING

**Muhammad Abbas[1,*], Allah Bakhsh[2], Muhammad Aleem[3], Muhammad Ashraf[1], Muhammad Bilal Idrees[4] and Noman Ali Buttar[5]**

**[1]Pakistan Council of Research in Water Resources, Khyaban-e-Johar Road, H-8/1, Islamabad, 44000, Pakistan; [2]Department of Irrigation and Drainage, University of Agriculture, Faisalabad, 38040, Pakistan; [3]College of Environment, Hohai University, 1-XiKang Road Nanjing, 210098, P.R. China; [4]Department of Civil and Environmental Engineering, Hanyang University, Seoul, 04763, South Korea ; [5]School of Agricultural Equipment Engineering, Jiangsu University, Zhenjiang, 21013, P.R. China**
***Corresponding author e-mail: m.abbasvirk@uaf.edu.pk**

Less water productivity has caused wastage of water. Water productivity can be increased by using drip irrigation on raised beds. For this purpose, study was conducted at Experimental Research Station, Post Agricultural Research Station (PARS), University of Agriculture Faisalabad (UAF); to compare crop yield, water applied and water productivity under drip irrigation on raised beds with conventional sowing. The experiment was laid out under Randomized Complete Block Design (RCBD). Three treatments $T_1$ (Bed sowing with drip irrigation),$T_2$ (Bed sowing with furrow irrigation) and $T_3$ (Ridge sowing with furrow irrigation) were designed and further replicated generating nine plots altogether. During research, field data related to germination, number of irrigations, crop water requirement were calculated. Furthermore, statistical analysis showed significant results for volume of water used by crop, percentage of water saving, grain yield, harvest index and maize water productivity for treatment $T_1$ (Bed sowing with drip irrigation). Treatment $T_1$ showed maximum water productivity, saving of water and increase in productivity by 10151 kg/ha, 3898 $m^3$/ha and 2.60 kg/$m^3$respectively followed by bed planting with furrow irrigation: 9248 kg/ha, 5697 $m^3$/ha 1.62 kg/$m^3$andridge sowing with furrow irrigation: 8210 kg/ha, 7297.08 $m^3$/ha and 1.12 kg/$m^3$ respectively. Therefore, from experimental results, it was concluded to adopt drip irrigation on bed planting for maize to improve water productivity.
**Keywords:** Water productivity, drip irrigation, crop yield, raised beds, bed planting

## INTRODUCTION

Pakistan is an agriculture based economic country shares major contribution of GDP by 21% and this sector contributes employment to 62% population of country (Economic survey of Pakistan, 2009-10). In country, water availability is becoming main problem, the availability of water per capita was 5650 $m^3$ in 1951; 1200 $m^3$ in 2003 also it may decrease to eight hundred $m^3$ in 2025. With raising population usage of water is additionally increasing. So there will be a competition for getting water to use for industrial utilization, agriculture and for drinking purposes.

The reveal of agriculture water is major part of Indus river basin on account of increasing demand every day but water needs for agriculture is the main market of good quality water by 93%. And utilization of fresh water in the world is estimated as 69% while 56% of this area lies in Asia (Cai and Rosegrant, 2003; Dawe, 2005). Due to demand in water supply; the availability of water is declining because the fast rate of depletion of groundwater, contamination of surface water with pollutants and degradation of water ecosystem. So there is need to conserve and preserve water resources (IFPRI and IWMI, 2002). After Wheat and rice Maize is 3rd major crop of country which shares major contribution of water for its growth. Throughout Pakistan cereal harvest has 0.13 kg/$m^3$ output of water where by in USA it is 1.56 kg/$m^3$, in China it is 0. 82 kg/$m^3$ in addition to in India it is 0.39 kg per $m^3$.

Farmers are utilizing traditional irrigation means for greater than a century which includes caused irrigation water wastage along with the loss connected with productive land caused by water logging resulting from over irrigation. There is certainly need to improve per system productivity connected with water and boost the efficiency connected with water. We can easily increase output of irrigation water by increasing water productivity, raising water use efficiency, good agronomic routines and by utilizing better in addition to judicious utilization of land in addition to water. It has been observed that Pakistan's water resources are limited, in agriculture, water usage for crop and plants is totally through irrigation, which require fresh and good quality of water and it is the primary consumer of fresh water. But the increase in population and industrialization has increased competition for taking fresh water for their usage.

Irrigation water management in this particular system is better and much less labor intensive in drip irrigation system while using furrows, when compared to traditional deluge irrigation system. The system of bed planting maize and rice for irrigated conditions in addition to for rainfall fed which has been adopted simply by in Northern West Mexico and today in Indian and Pakistan way too, offers in addition to innovative option for diversifying maize and rice production routines. Wheat options may yet again make critical contributions towards world rice production if bed growing of rice is generally adopted (Pingali, 1999). Therefore, it has become need of hour to fulfill the irrigation requirements, the farmers must be engaged to use water saving technologies at their fields which not only increase water use efficiency but also tend to increase crop production. The modern techniques have shown that new water saving technologies increase water application efficiency. These new water saving technologies include pressurized drip irrigation. So to reduce scarcity of water, water resources management is compulsory. Drip irrigation system has been adapted by farmers since last thirty five years. This system has provided the farmers more benefits over conventional methods and became a cause to increase their crop productivity and reduction of labour cost at their fields. (Bozkurt *et al.*, 2006). Also need for water is increasing geometrically while the availability is reducing. This all has been happened due to climatic and environmental changes; increasing urban population; need of water for irrigation of parks; and development of new housing schemes (Kharrou*et al.,* 2011).

In order to preserve water resources of country, we must increase crop water productivity such that farmers may get more yield by applying less quantity of water, this must happen when we will change our way of conventional application of water into pressurized and; efficient irrigation systems. These irrigation systems will not only save irrigation water but also increase crop productivity. For this purpose, Experiment was conducted to show water saving by bed planting. And results showed that bed planting is an efficient water saving technology (Mascagni *et al.,* 1995).

## MATERIALS AND METHODS

The experimental site was selected at PARS along Jhang road, Faisalabad. Its coordinates are 30°57'36''N 72°51'58''E. Faisalabad has a semiarid (0.05 - 0.2 p/pet) climate. The land area is cultivated; still some natural vegetation is preserved. The landscape is mostly covered with irrigated croplands. The climate is classified as a subtropical desert (low latitude desert), with a subtropical desert scrub bio zone. The soil in the area is high in calcisols, cambisols, luvisols (cl), soils dominated by calcium carbonate as powdery lime or concretions.

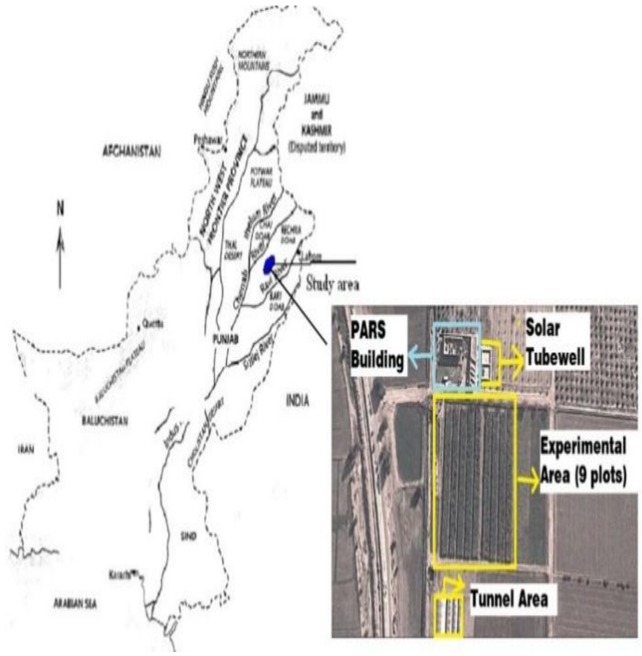


**Figure 1:Location of experimental site**

June is warmest with an average temperature of 42.2 °C at noon. January is coldest with an average temperature of 4.8 °C at night. It has distinct cold and warm seasons, like cold winters and warm summers. Temperatures drop sharply at night. Winter can have some frost days, with the coldest month most often being January. May is on average the month with most sunshine. Rainfall and other precipitation have no distinct peak month. 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. A standard procedure was followed using hydrometer to analyze soil texture. A soil sample of 40 gm was dried in air. 500 mi of sodium hexametaphosphate, acting as dispersing agent was added to the soil sample. Distilled water (150 ml) was also added in the beaker to facilitate the reaction. After 24 hours of incubation at room temperature, solution was stirred with a mechanical shaker for 10 minutes and transferred to 1000 ml graduated cylinder. The suspension was shaken vigorously with metal plunger. Initial reading was taken after 40 seconds of shaking and final reading was noted after 4 hours on bouyoucos hydrometer. Soil texture class was determining using United States Department of Agriculture (USDA) triangle.

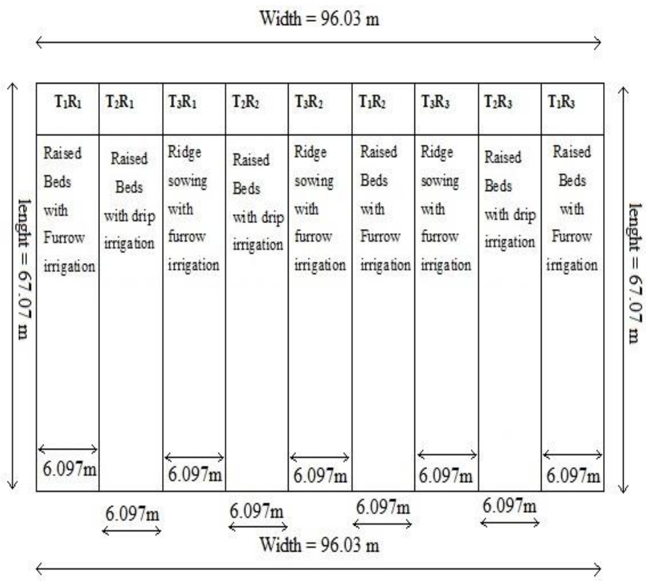


**Figure 2:Treatments Plan and Layout**

Before sowing of maize land was prepared. First land was leveled with the laser land leveler. After that cultivation was done with rotavator and then with tine. Planking was also done with planker. The recommended seed variety of maize Pioneer was sown at a rate of 19.76 Kg/hectare with row to row distance of 45 cm and plant to plant distance of 18 cm. Maize was sown on February 22, 2013. Fertilizers such as Nitrophas, NPK and Urea were applied. Crop management and water application data were collected throughout the season. The irrigation water was applied according to crop water requirement. The measurements which involve characterization of the soil solution and its constituents and of the composition of the organic and inorganic phases in soil, are broadly termed chemical analysis. A core sample was used for bulk density determination. Undisturbed soil samples were taken from 0-15, 15-30, 30-45 and 45-60 cm depths. At first the samples were weighed and then put in an oven at 105 °C for 24 hours and weighed again. Soil bulk density was calculated using equation.

$$BD = M_s / V_b$$

Where BD = Bulk Density of soil, $M_s$ = Mass of oven dry soil (g), $V_b$ = Volume of soil ($cm^3$)

The purpose of irrigation scheduling is to determine the exact amount of water to apply to the field and the exact timing for application. The amount of water applied is determined by using a criterion to determine irrigation need and a strategy to prescribe how much water to apply in any situation.The efficiency of water in agricultural production is generally low. Only 40-60% of water is used effectively by the crop, the rest of the water is lost in the system or in the farm either through evapotranspiration, runoff, or by percolation into the groundwater. Irrigation scheduling, if properly managed can offer a good solution to improve water efficiency in the farm.

Various methods and tools have been developed to determine when crop require water and how much irrigation water needs to be applied. These include the various soil and plant monitoring methods as well as the more common soil water balance and scheduling simulation models.Over irrigation wastes water, energy and labor; leaches expensive nutrients below the root zone, out of reach of plants; and reduces soil erosion, and thus crop yields.

Under irrigation stresses the plant and causes yield reduction. Calculations of water and irrigation requirements utilize inputs of climatic, crop and soil data as well as irrigation and rain data the climatic input data required reference Evapotranspiration ( monthly decade ) and rain fall ( monthly decade daily) reference Evapotranspiration calculated from actual temperature humidity sun shine radiation and wind speed data. The calculation of reference Evapotranspiration ($ET_0$) is based on FAO Penman Monteith method (FAO, 1998). Input data include monthly and 10 daily for temperature. (Maximum and minimum), humidity,sunshine, wind speed. Crop water requirements (Et crop) over the growing season are determined from ETo and estimates of crop evaporation rates, expressed as crop coefficient (Kc), based on well- established procedures (FAO, 1977) , according the equation 3.4 ( Doorenbos and Pruitt 1975).

$$ETc = Kc \times ETo$$

Where,ETc = Crop Evapotranspiration, (mm $day^{-1}$), ETo = Reference Evapotranspiration, (mm $day^{-1}$)

Evaporation pans provide a measurement of the combined effect of temperature, humidity, wind speed and sunshine on the reference crop evapotranspiration ETo, Many different types of evaporation pans are being used. The best known pans are the Class A evaporation pan (circular pan). The principle of the evaporation pan is the following:

The pan is installed in the field

The pan is filled with a known quantity of water (the surface area of the pan is known and the water depth is measured)

The water is allowed to evaporate during a certain period of time (usually 24 hours). For example, each morning at 7 o'clock a measurement is taken. The rainfall, if any, is measured simultaneously

After 24 hours, the remaining quantity of water (i.e. water depth) is measured

The amount of evaporation per time unit (the difference between the two measured water depths) is calculated; this is the pan evaporation: E pan (in mm/24 hours)

The E pan is multiplied by a pan coefficient, K pan, to obtain the ETo.

$$ETo = K\ pan \times E\ pan$$

ETo = reference crop evapotranspiration, K pan: pan coefficient, E pan: pan evaporation

***Determination of K pan:*** When using the evaporation pan to estimate the ETo, in fact, a comparison is made between the evaporation from the water surface in the pan and the evapotranspiration of the standard grass. Of course the water in the pan and the grass do not react in exactly the same way to the climate. Therefore a special coefficient is used (K pan) to relate one to the other.The pan coefficient, K pan, depends on:

- The type of pan used
- The pan environment: if the pan is placed in a fallow or cropped area
- The climate: the humidity and wind speed

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 cop water requirement. it is also fact that too less or much amount of water applied to the crop can also hinder the growth and development of crop. For this purpose amount of water applied to each plot was calculated by using the equation 3.5 (Michael, 1978).

$$D=(Q\times T)/A$$

Where,Q = discharge from the tube well $m^3$/sec, T = time in seconds, A = area of experimental unit in square meter, D = depth of water applied in meter

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 degree c. and weighed again. An area of 1 $m^2$ was harvested from each plot at random avoiding the border effects. The grins 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. 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. Crop water use efficiency, defined as the ratio of grain yield obtained to the water applied to crop (Mahmood and Ahmed, 2005). In this study crop water use efficiency was calculated from equation 3.6.

$$WUE = Y/TIW$$

Where, WUE = Water use efficiency, kg/$m^3$, Y = Grain yield, kg/ha, TIW = Total Irrigation Water applied, $m^3$/ha

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 (Steel and Torrie 1980). Treatments means were compared using Duncan and LSD at 5% significance level.

## RESULTS AND DISCUSSIONS

Soil texture analysis was carried out at soil and water testing laboratory for research at Ayub Agricultural Research Institute, Faisalabad. The soil of study area can be classified as sandy clayey loam with 56% sand, 20% silt and 24% clay. The organic matter in the soil is 0.62% with a pH in the range of 8.27-8.32 Table 1. The crop management operations were carried during experiment were explained in Table 2.

**Table 1: Basic soil parameters and their analysis**

| Soil Analysis of Experiment | | | | |
|---|---|---|---|---|
| **Determination** | **Unit** | **Depth(ft)** | | |
| | | **1** | **2** | **3** |
| Sand | % | 56 | 51 | 50 |
| Silt | % | 20 | 22 | 23 |
| Clay | % | 24 | 27 | 27 |
| pH | | 8.3 | 8.32 | 8.27 |
| EC | $dSm^{-1}$ | 0.46 | 0.465 | 0.722 |
| Nitrogen | % | 0.03 | 0.017 | 0.009 |
| Phosphorous | ppm | 3.89 | 2.47 | 1.97 |
| Textural class | | Sandy clay loam | Sandy clay loam | Sandy clay loam |

Water was applied according to crop water needs on daily basis. The value of Evapotranspiration was calculated by pan evaporation method. In this procedure total amount of ETc was calculated as 480 mm per season. While maximum value per day was found on 1st May 2015 which was 8.85 mm/day while low value was determined as 0.36 mm/day on February 2015. It was observed that at initial stage water consumption was low as crop do not need higher water while it was maximum in growth stage which was in April and May months respectively and at maturing stage this value started decreasing. Amount of seasonal water was used is recorded in graph.

The grain yield of Raised Bed planting with furrow irrigation ($T_1$) with three replications are (10261 kg/ha, 10142 kg/ha, 10198 kg/ha). For bed sowing with drip irrigation treatment ($T_2$), the grain yield obtained are (10472.8 kg/ha, 9840 kg/ha, 10140 kg/ha) and grain yield of ridge furrow sowing method treatment ($T_3$) are (8200 kg/ha, 8460 kg/ha, 7970 kg/ha). The average grain yields of treatments (T1, T2 & T3) are shown graph. According to graph the maximum average grain yield is gained in case of drip treatment i.e. 10,282 kg/ha. The minimum average grain yield is gained in case of ridge furrow method treatment i.e. 8210 kg/ha and the average grain yield of bed sowing with furrow irrigation treatment ($T_1$) is in between of $T_2$ and $T_3$. i.e. 10,200 kg/ha.

Biomass is a biological mass. Biological term refers to living organisms. So, biomass was found by measuring the weight of plants of all treatments (T1, T2 and T3). I took a weighing scale into the field and weight the few samples of all treatment as shown in table 4.5. The whole of weight of plant was measured. It includes the plant corn stover and corn kernel (non-grain part is called stovel and grain part is called kernel). Therefore, the average Biomass yield that was obtained at the end of experiment is shown in table. The average biomass yield of bed sowing with furrow irrigation (T1) was 227,764.5

**Table 2: Crop operation and management practice schedule**

| Sr. | Activities | Year: 2015 |
|---|---|---|
| 1 | Laser land leveling, Cultivation with Rotavator, Cultivation with tine, Planking | February 24, 2015 |
| 2 | Sowing, At sowing time Nitrophas was applied on T1 & T3 @ 340 kg/ha, At sowing time Nitrophas was applied @166 kg/ha for T2 | February 25, 2015 |
| 3 | Mixture of Urea, Nitrophas& NPK(20-20) in ratio of (2:2:7)kg in 220 liter of water, to make 11 kg total mixture, 1 kg of this mixture was applied every week till maturing stage @6.67 kg/ha for T2 | February 20, 2015to Harvesting |
| 4 | In Drip, irrigation was applied for first 30 irrigations @ 20 minutes/day | February-June, 2015 |
| 5 | 1st Irrigation for T1 and T3 | February 25, 2015 |
| 6 | At 2nd irrigation for T1 & T3 Urea applied @ of 83.2kg/hectare, 2nd Irrigation For T1 and T3 | March 02, 2015 |
| 7 | 3rd Irrigation For T1 and T3, Urea applied @ 166kg/hectare | March 13, 2015 |
| 8 | 4th Irrigation For T1 and T3 | March 21, 2015 |
| 9 | For T2, Next 30 irrigations applied @ 40 minutes/day | April 4-May 4 2015 |
| 10 | 5th Irrigation For T1 and T3 | March 23, 2015 |
| 11 | 6th Irrigation For T1 and T3 | March 27, 2015 |
| 12 | At 6th irrigation Nitrophas was applied for T1 & T3 @ 83.3kg/hectare | March 18, 2015 |
| 13 | 7th Irrigation For T1 and T3 | April 12, 2015 |
| 14 | 8th Irrigation For T1 and T3 | April 22, 2015 |
| 15 | For T2, At 9th irrigation Ammonium nitrate was applied @ 83.3kg/hectare | April 28, 2015 |
| 16 | 9th Irrigation For T1 and T3 | May 12, 2015 |
| 17 | Harvesting | June 14, 2015 |

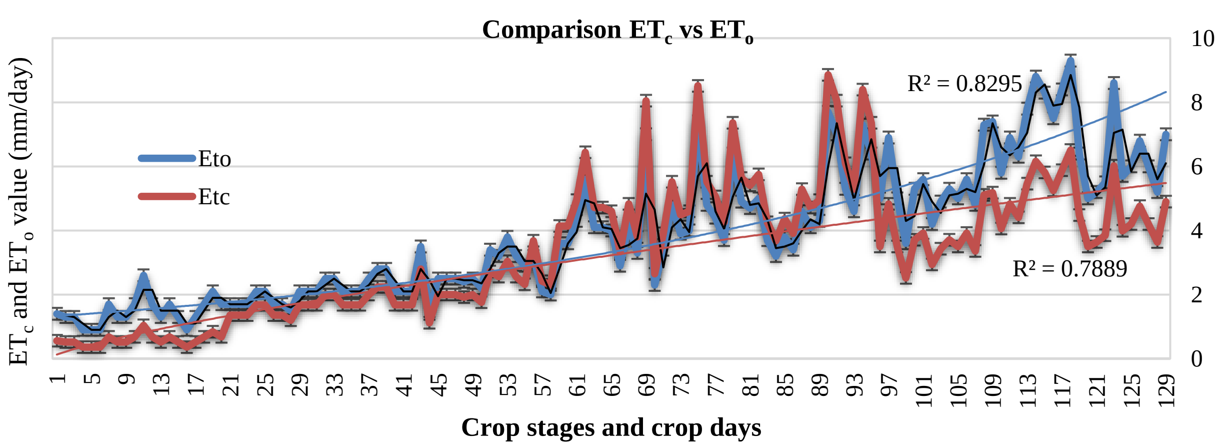


**Figure 3: Graphical representation of $ET_c$ and $ET_o$ on daily basis**

kg/ha. For treatment (T2), the biomass yield obtained was 131,779 kg/ha. And the average biomass yield was 236, 209.6 kg/ha in case of Ridge furrow sowing (T3). After that grain yield and harvest index of all treatments were plotted to check the homogeneity and significance levels.

Volume of water used by any crop is just like the fuel consumption estimation of any vehicle. Here's we can consider the soil like a fuel tank of vehicle. 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.

Essentially all plants require water for survival. Crop water utilize is the water utilized by a product for development and cooling purposes. Each crop uses water according to its needs. Some crops need more water like rice and some need less water like melon and bean.

Water productivity refers to the value of goods and services produced per unit of water consumed. Here, the term water

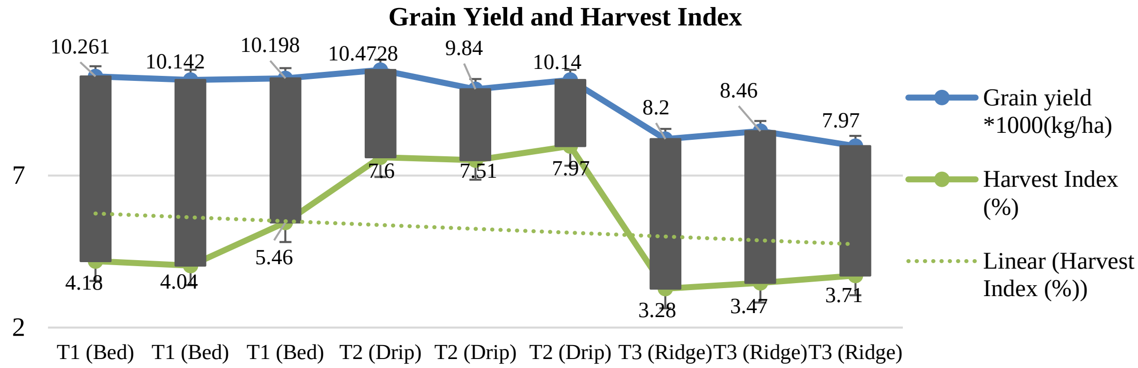


**Figure 4: Grain Yield and Harvest Index**

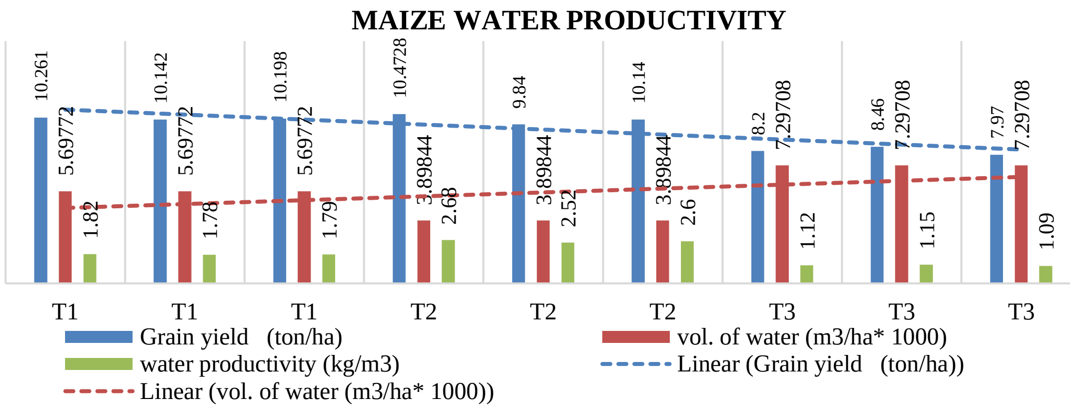


**Figure 5: Maize Water Productivity.**

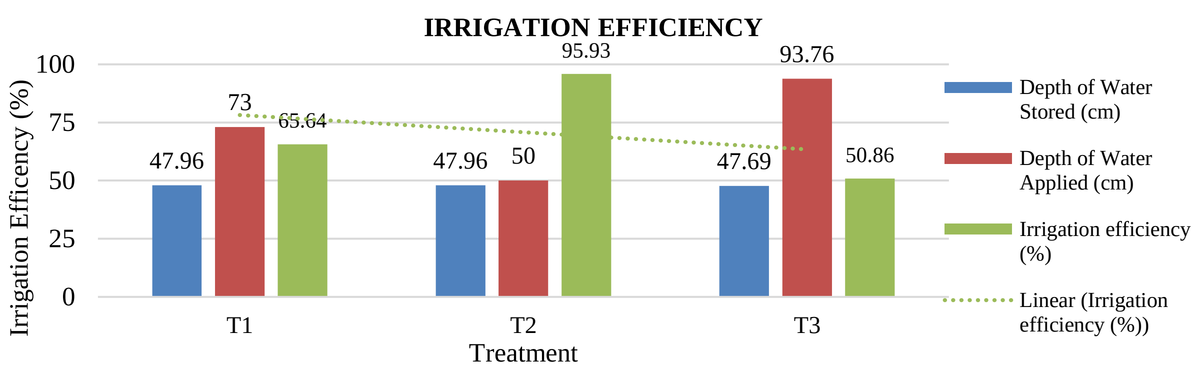


**Figure 6: Irrigation Efficiency**

profit is utilized only to signify the sum or quality of item over volume or worth of water exhausted or redirected. The worth of the item could be communicated in distinctive terms (biomass, grain, and cash). For instance, the alleged 'harvest for every drip' approach concentrates on the measure of item for every unit of water. An alternate approach recognizes contrasts in the nourishing qualities of distinctive harvests, or that the same amount of one yield encourages more individuals than the same amount of an alternate crop. The point when talking about sustenance security, it is significant to record for such criteria an alternate concern is the manner by which to express the social profit of agrarian water benefit. All the choices that have been inferred could be compressed by the expressions 'supplement for every drip', 'capita for every drip', 'employments for every drip', and 'maintainable vocations for every drip'. There is no special meaning of benefit and the worth recognized for the numerator may hinge on upon the center and also the accessibility of information. On the other hand, water benefit described as kilogram for every drip is a helpful notion when looking at the profit of water in diverse parts of the same framework or stream bowl and additionally when looking at the gainfulness of water in farming with different parts.

***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.The irrigation efficiency is subdivided into two other efficiencies. The conveyance efficiency which represents the efficiency of water transport in canals, and the field application efficiency which represents the efficiency of water application in the field.

***Conclusions and Recommendations*:** After obtaining the results of the experiment it had been found that drip irrigation is useful technologies for farmers. It saves not only 46% of irrigation water but also found best to increase crop productivity. The irrigation efficiency was found maximum in case of drip technique, i.e., 95.93%, 50.86% in case of conventional technique and 65.84% pertaining to Bed furrow irrigation system. Water productivity was found maximum in case of drip 2.60 kg/m$^3$, for bed furrow irrigation treatment it had been 1.796 kg/m$^3$ and also for regular system 1.12 kg/m$^3$. From experiment results, it is concluded that drip irrigation is good to be adopted by farmers to increase water productivity. If we compare total water used between drip irrigation and conventional ridge furrow irrigations then we come to know that 46.72 % water was saved in drip irrigation than conventional method.

- Drip irrigation under bed planting is found useful and 46% water saving technique in comparison to conventional method.
- Drip irrigation under bed planting must be used because 22% more yield was obtained in comparison to conventional method.
- Drip irrigation technology under bed planting must be used to improve water productivity as water productivity is found 2.60 kg/m$^3$ and in case of conventional method, it is 1.12 kg/m$^3$.

***Acknowledgements:*** The authors wish to thank the USDA-ICARDA for financial support. This work has been conducted at Water Management Research Centre, Faisalabad.

## REFERENCES

Cai, X. and M. Rosegrant. 2003. World water productivity: current situation and future options. In: J.W. Kijne, R. Barker and D. Molden (eds.), Water productivity in agriculture: limits and opportunities for improvement. CABI, Oxford, pp.163-178.

Dawe, D. 2005. Increasing water productivity in rice based systems in Asia – past trends, current problems and future prospects. Plant Production Science. 8:221-230.

Abdrabbo, A and A. Kheira. 2009. Comparison among Different Irrigation Systems for Deficit-Irrigated Corn in the Nile Valley. Agricultural Engineering International: the CIGR Ejournal. Manuscript LW 08 010. Vol. XI.

Bozkurt, Y., A. Yazar., B. Gencel and M. S. Sezen. 2006. Optimum lateral spacing for drip irrigated corn in the Mediterranean Region of Turkey. Agriultural water management. 85:113–120.

Doorenbos, J. and W. O. Pruitt. 1975. Guidelines for predicting crop water requirements. In: FAO Irrigation and Drainage Paper No. 24, Food and Agriculture Organization, Rome.

FAO. 1977. Yield response to water by J. Doorenbos and A. H. Kassam. Irrigation and drainage paper no.33.FAO, Rome.

FAO. 1998. Crop evapotraspiration by R.Allen, LA. Pereira, D. Raes and M. Smith. FAO irrigation and drainage paper no. 56. FAO, Rome.

IFPRI and IWMI, 2002. Averting an Impending Crisis. Global water outlook to 2025. A 2020 Vision for Food, Agriculture, and the Environment Initiative.

Kharrou, M. H., S. E. Raki., A. Chehbouni., B. Duchemin., V. Simonneaux., M. Lepage., L. Ouzine and L. Jarlan. 2011. Water Use Efficiency And Yield of Winter Wheat Under Different Irrigation Regimes In a Semi Arid Region. 2 :273-282.

Mahmood, N. and R. N. Ahmed. 2005. Determination of water requirements and Response of wheat to irrigation at different soil moisture depletion levels. International journal of agriculture and biology.7:812-815.

Mascagni, H.J., T. C. Keisling, W. E. Sabbe, M. May, L. R. Oliver and E. D. Vories. 1995. Wheat production on raised beds on clayey and silt loam soils. Comm.Soil Sci. Plant Anal. Pages. 26:503-513.

Michael, A. M. 1978. Irrigation theory and practices, Vikas publishing house (Pvt.).

Pingal, L.P. 1999. Sustaining rice-wheat production systems: Socioeconomic and policy issues. Consortium Paper Series 5. pp 99. Rice teal Consortium for the Indo-Oangetic Plains, New Delhi. India.

Steel, R. C. D. and J. H. Torrie. 1980. Principles and procedure of statistics. 2nd edition. McGraw Hill Book. Co. New York.