WHEAT (TRITICUM AESTIVUM) CROP RESPONSE UNDER DRIP IRRIGATION SYSTEMS IN CLAY LOAM SOIL

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ABSTRACT

The aim of this study was to estimate the wheat yield response to drip irrigation systems and the attributed water productivity and saving water indices under clay loam soil conditions of semi tropical regions. A field experiments was conducted at demonstration unit of the College of Agricultural Engineering, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India, during the rabi seasons of 2011-12 to study the effect of drip irrigation on water productivity and yield attributes of wheat crop. To achieve the objectives of this study two irrigation methods were investigated "Border irrigation method and surface drip irrigation method". A field experiment with four treatments (3 drip + 1 border) was carried out. Statistically this work was designed as Randomized block design and analysis by two-way Analysis of Variance (ANOVA). Results revealed that water saving of about 28.42% higher in case of drip irrigation compared with the border irrigation system. Data also revealed that water

productivity of drip irrigated wheat was 24.24% more than the border irrigated wheat. However there was a slightly decrease of 10.8% in the grain yield. This may be due to the wheat plants had exposed to higher water-stress during the growing stages. Finally, It can be concluded that good management of irrigation water under drip irrigation is promising for higher water productivity and can be adopt as alternative irrigation system for irrigating intensive field crop like wheat, but more studies have to be conducted under similar field conditions.

Keywords: Drip Irrigation, Water Productivity, Border Irrigation, Wheat Irrigation, Water Use Efficiency.

1. Introduction

Recognizing the importance of sustainable water use efficiency in agriculture, a number of demand management strategies (like water pricing, water users association, turnover system) have been introduced since the late seventies to increase the water use efficiency especially in the use of surface irrigation water. While various strategies introduced for improving the water use efficiency have been continuing, the net impact of these strategies in increasing water use efficiency is not very impressive [1].

Physical and economic scarcity of water across regions has forced water resources economists and scientist to critically analyze different options for managing water. A study by the International Water Management Institute (IWMI) shows that around 50% of the increase in demand for water by the year 2025 can be met by increasing the effectiveness of irrigation.

Wheat (*Triticum aestivum*) is one of the most important staple food grains of human race. India produced 94.88 million tones of wheat during the year 2011-12 which is about 13.53 percent of world production [2]. It is the second largest producer of wheat in the world. India is also the second largest in wheat consumption after China. Wheat is the second most important cereal in India after rice, contributing substantially to the national food security by providing more than 50% of the calories to the people who mainly depend on it.

Presently in India, most of area under wheat crop is irrigated by border irrigation, with very poor water use efficiency of about 66.5% [3] because of huge conveyance and distribution

losses [4] [5]. India's water resources, particularly in the context of agriculture, are facing extreme stress. The country sustains 16 percent of the world's human population and 20 percent livestock population with just 3 percent of the world's water [6]. With changing lifestyles and rising water consumption in urban areas, water for agriculture is under threat from other users.

One of the demand management strategies introduced recently to control water consumption in Indian agriculture is micro irrigation (MI), which includes mainly drip and sprinkler irrigation method. Among all the irrigation methods, the drip irrigation is the most efficient and reported to help achieve yield gains of up to 100%, water savings of up to 40-80%, and associated fertilizer, pesticide, and labor savings over conventional irrigation systems [7]. Drip irrigation can be practiced successfully to irrigate wide range of crop variety especially in vegetables, orchard crops, flowers and plantation crops but on the other hand, limited studies had been conducted under field crops like wheat. Drip irrigation saves more than 20 percent of irrigation water [8] as compare to surface irrigation in wheat crop, and for producing 1 kg of wheat about 1000 lit of irrigation water is required [9]. For total wheat production of India we can save 18976 M m^3 of water per year by adopting drip irrigation method in wheat crop. The adoption of drip irrigation has significant bearing on the society as a whole and generates various positive and negative externalities [10]. Applicability and success of drip irrigation changes with soil type, climate and management of system of irrigation and hence it has to be tested for region specific.

Few technically, economically and environmentally feasible studies had been focused on the application possibility of the alternative drip irrigation systems (surface and subsurface drip); an evaluation and performance consideration exists under intensive field crop conditions, which had been carried out by [11][12][13][14][15][16]. Therefore, this study has the priority on emphasizing and description of the engineering design criteria to evaluate and determine the suggested alternative irrigation system and technique and its effect on wheat crop yields in clay loam soils of Indian agriculture.

2. Materials and Methods

2.1 Site Description:

To achieve the objectives of this study, a field experiment was carried out during the rabi seasons of 2011-12 at demonstration unit of the College of Agricultural Engineering, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh, India. Research site lies between latitude $23^0$13'05"N and $79^0$57'39"E. The climate of the study area was semi tropical and annual temperature was 25.7^0C and average annual rainfall of the area was 1300 mm. the soil of the study area was clay loam soil with contain clay 39.52%, silt 27.82% and looam 32.65%.

2.2 Experimental Details:

Wheat (GW-273) was sown on 26th December 2011 by the tractor drawn seed cum fertilizer seed drill at a seed rate of 100 kg/ha and 20 cm row spacing. Recommended fertilizer dose 120:60:40 of N:P:K was applied to the crop, as basal dose 18:60:40 of N:P:K was applied at the time of sowing and remaining N was supply in three equal dose after 25, 50, 75 days from sowing. Wheat was harvested on 24th April 2012.

A overhead tank was used as a pressurized water source for drip irrigation system. Main line of size 75mm and submain line of size 50mm both made of PVC delivered irrigation water through LDPE laterals of 16 mm outer diameter with 6m length, built-in drippers with discharge of 4 lph/40cm spacing at 1.0 bar operating pressure. All details about the experiment design is shown as in figure 1.

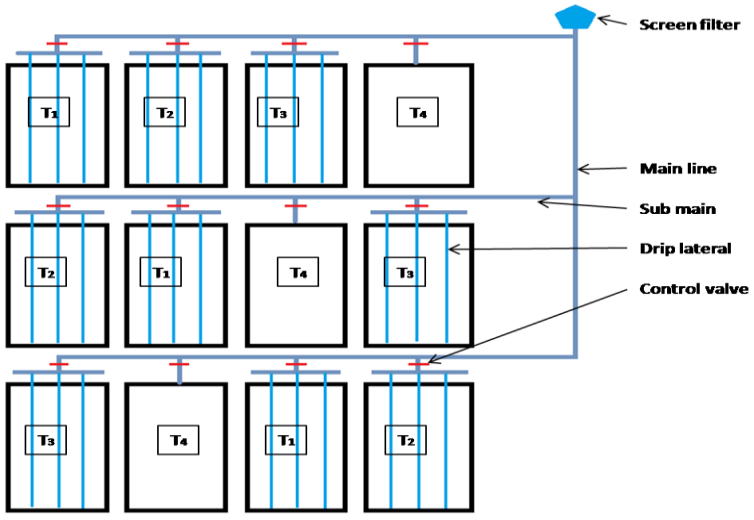

Figure 1: Layout of Experiment Design

In order to achieve the objectives of this study two irrigation methods were investigated "Border irrigation method and surface drip irrigation method". A field experiment with four treatment (3 drip + 1 border) was carried out, under drip irrigation three treatments based on lateral spacing are T_1 – 40 (one lateral for two rows), T_2 – 60 (one lateral for three rows), T_3 – 80 cm (one lateral for four rows) and under border irrigation T_4 (two border of 2.5 m width and 20 m long) with three replication. So the experiment include total 12 plot of size 5m x 20m and total experiment area of 1200 m^2 (20m x 60 m) was investigated as shown in figure 1. Statistically this work was designed as Randomized block design and analysis by two-way Analysis of Variance (ANOVA).

After the installation of drip irrigation system, it was tested for design discharge, uniformity of emitters and for clogging problem. At a pressure of 1kg/cm2 the average discharge per emitter was measured and the Christiansen uniformity coefficient was worked for analyzing the uniformity of emitter discharge, which was found 98.4%. The Christiansen uniformity coefficient was calculated as:

$$CCU = \left[1 - \frac{\sum_{i=1}^{n} |D_i - \bar{D}|}{\sum_{i=1}^{n} D_i}\right]$$

Where,

D_i is the discharge or depth of irrigation of an emitter,

$\bar{D}$ is the mean discharge of all emitters

n is total number of observations/emitters

Wheat crop under drip irrigation system was irrigated as per crop water requirement in every 3rd day. The control valve of a particular treatment was opened for a calculated time so that required depth of irrigation will supply to the plot. Under border irrigation method; six irrigations at critical stages were given to the wheat crop. Total 34.5 cm depth of irrigation water was applied to the treatment under drip irrigation system (T_1, T_2 and T_3) and total 48.2 cm depth of irrigation was applied under border irrigation (i.e. T_4). The amount of irrigation water was calculated on the basis of crop water requirement by the fallowing formula.

PE x Pc x kc

$$D = \frac{\text{---------}}{IE}$$

Where,

D- Net depth of irrigation (mm).
PE- Pan evaporation (mm/day).
Pc- Pan coefficient.
Kc- Crop coefficient.
IE- irrigation efficiency.

Harvesting of crop was done manually with the help of sickle when it attained maturity. Each plot were harvested, bundled and tag separately. After sun drying, threshing was done by a 1hp electric operated thresher. Bundled of each plot were weighted by electronic balance separately. Then threshed material from each row kept separately from the straw by winnowing with the help of hand pan *(supa)*. After that the clean grains were weighted plot wise and grain, straw and biological yields were determined in quintal per hectare. For test weight, sample of grains were randomly drawn from the produce of each plot and then thousand grains were carefully counted. The counted grains were weighted on an electric balance and weight was recorded in grams. Harvest index and water productivity were calculated with fallowing formula.

$$\text{Harvest Index} = \frac{\text{Economic Yield}}{\text{Biological Yield}}$$

$$\text{Water productivity} = \frac{\text{Grain yield (kg/ha)}}{\text{Total water applied (cm)}}$$

3. Result and Discussion

The data obtained from this study will be presented and discussed as fallows:

Irrigation water:-

Results revealed that water saving of about 28.42% of irrigation water in case of drip irrigation compared with the border irrigation system as total 34.5 cm depth of irrigation water was applied to the treatment under drip irrigation system (T_1, T_2 and T_3) and total 48.2 cm depth of irrigation was applied under border irrigation (i.e. T_4). This is due to the reductions in deep percolation, in surface runoff and in evaporation from the soil.

3.1 Yield components

Table 1: Effect of Treatment on Yield Attributes and Water Productivity.

Treatment	Yield attributes					Water productivity (kg/m^3)
	Biological yield (q/ha)	Grain yield (q/ha)	Straw yield (q/ha)	Test weight (gm)	Harvest index (%)	
T_1	89.22	43.5	45.72	40.74	48.75	1.26
T_2	83.73	42.61	41.12	39.24	50.94	1.23
T_3	83.07	40.34	42.57	37.49	48.63	1.17
T_4	98.01	47.77	50.11	42.94	48.66	0.99
CD at 0.05	8.15	5.56	7.23	2.85	5.82	0.14

From the table 1 and figure 2, the data pertaining to biological yield, grain yield and straw yield clearly showed that all yield components significantly influenced by drip irrigation method. Superiority of T_4 (border irrigation) in producing higher yield in all component was recorded, however grain yield of T_1 and T_2 are alike with T_4 and only T3 and T4 differ significantly. These means that on a long term scale the smaller dose of irrigation water could be distributed efficiently along the two and three line of wheat crop by a single drip lateral and achieve high yield equivalent to border irrigation method.

Treatment T3 (four line per lateral) show significantly low yield as compare to T4 (border irrigation) may be due to weak distribution of moisture under this condition.

Irrigation treatments showed significant effect on test weight. Bolder seed was recorded in border irrigated wheat and was superior to all drip irrigated treatments. Drip irrigates wheat show homogeneity in test weight; however there is increase in test wt. as lateral spacing decreases. This may be due to moisture stress in outer side rows of crop in maturity stage.

A different irrigation treatment does not show any significant effect on harvest index. From the statistical analysis, the magnitude of mean value of harvest index are in the order of T2>T1=T2=T3. These means that there is an equal proportion of production of grain and straw yield.

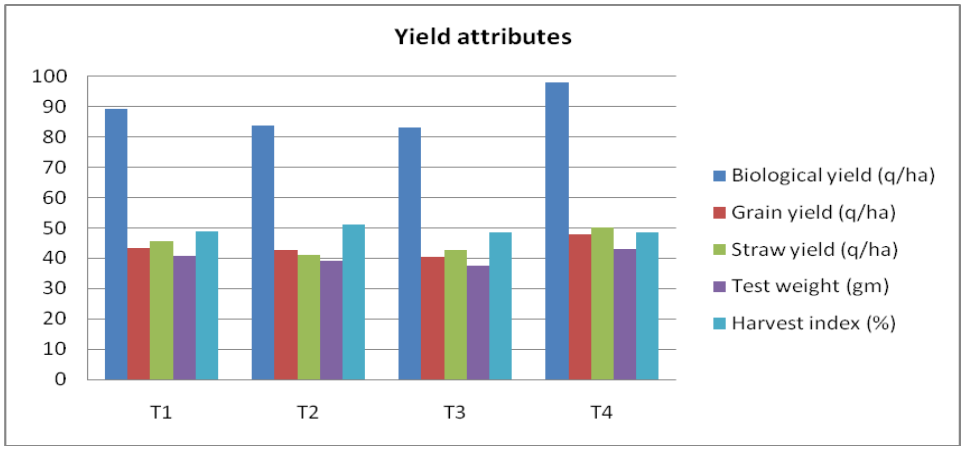

Figure 2: Effect of Treatment on Yield Attributes.

3.2 Water productivity:-

Statistical analysis shows highly significant differences for water productivity of wheat under different irrigation treatment. Data in table 1 and from figure 3, shows that water productivity is decreases as lateral spacing increases and it found minimum in treatment T4 (border irrigation). The magnitude of mean values is in order T1=T2>T3>T4. This may be due to the higher water losses in deep percolation, in surface runoff and in evaporation from the soil in border irrigation. From the analysis it can be tackled another facts about the good management of irrigation water leads in high water productivity and could be achieved by saving irrigation water under drip irrigation.

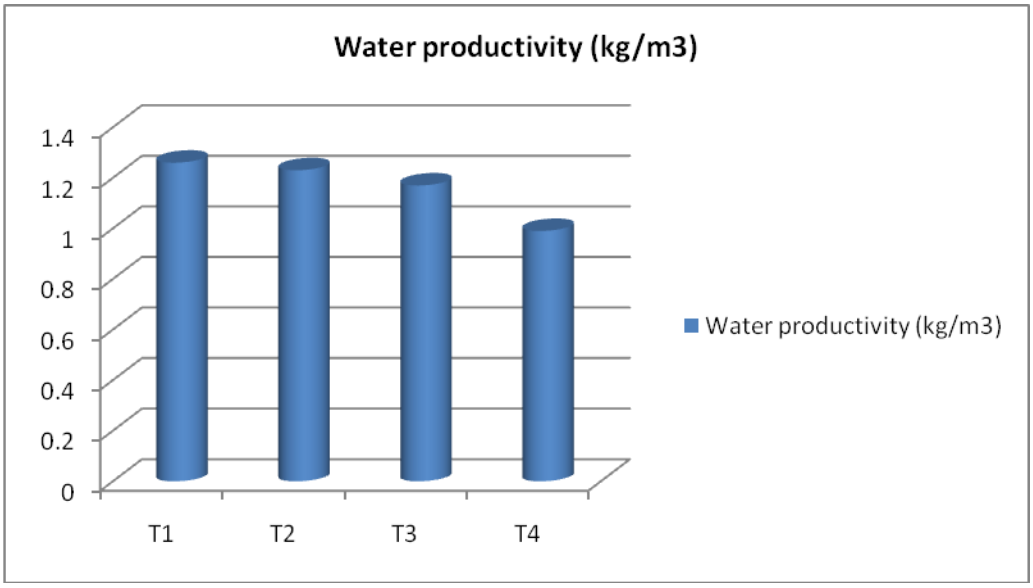

Figure 3: Effect of treatment on Water Productivity

4. Conclusions

From the aforementioned discussion, the data emphasized the success of drip irrigation in the cultivation of wheat crop. It is suggested to irrigate wheat crop under drip irrigation system with three line of wheat per lateral to obtain the higher water productivity of 24.24% as compare to border irrigation method. However there is decrease of 10.8% in the grain yield.

Finally, good management of irrigation water under drip irrigation is promising for higher water productivity and can be adopt as alternative irrigation system for irrigating intensive field crop like wheat, but more studies have to be conducted under similar field conditions.

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