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Maximizing Water Productivity and Yields of Wheat Based on Drip Irrigation Systems in Clay Loam Soil

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***Abstract*— Maximizing water productivity is one of the most important police in developing countries like India. Therefore, the aim of this study was to estimate the wheat yield response to drip irrigation systems and the attributed water use efficiency and saving water indices under clay loam soil conditions of semi tropical regions. A field experiments was conducted at the field of Jawaharlal Nehru Krishi Vishwa Vidyalaya (JNKVV), 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. Results revealed that water saving of about 9.7% higher in case of drip irrigation compared with the solid-set sprinkler irrigation system. The wheat grain yield and 1000 grain wt. (test wt.), data indicated that in drip irrigation grain yield was 12.14% and test weight was 17.86% more than the sprinkler irrigated wheat. However there was a slightly reduction of 2.08% in biological yield. This may be due to the wheat plants had exposed to higher water-stress during the growing stages. Data also revealed that water productivity of drip irrigated wheat was 21.76% more than the sprinkler irrigated wheat. It can be concluded that the alternative irrigation system (drip irrigation) has an effective way for irrigating intensive field crops, but more studies have to be conducted under similar field conditions.**

Key words: Drip irrigation, Water productivity, Sprinkler irrigation, Wheat irrigation.

I. INTRODUCTION

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 [7]. 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 flood irrigation, with very poor water use efficiency. Available estimates indicate that water use efficiency under flood method of irrigation is only about 35 to 40 percent because of huge conveyance and distribution losses [12], [8]. 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 [5]. With changing lifestyles and rising water consumption in urban areas, water for agriculture is under threat from other users. 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.

Though India has the largest irrigated area in the world, the coverage of irrigation is only about 40 percent of the gross cropped area as of today. One of the main reasons for the low coverage of irrigation is the predominant use of flood (conventional) method of irrigation, where water use efficiency is very low. Considering the water availability for future use and the increasing demand for water from different sectors, a number of demand management strategies and programmes have been introduced since late seventies in India to increase the water use efficiency, especially in the use of surface irrigation water. While the various strategies introduced to improve the water use efficiency, the net impact is not very impressive as of today.

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 it 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 [9] as compare to surface irrigation in wheat crop, and for producing 1 kg of wheat about 1000 lit of irrigation water is required [6]. 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. 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 [1], [2], [3], [4], [11] and [14]. 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.

II MATERIALS AND METHODS

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, JNKVV, 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%.

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.

Irrigation Systems Description:

In order to achieve the objectives of this study two irrigation methods were investigated "sprinkler irrigation method: solid-set sprinkler irrigation system and drip irrigation method: surface drip irrigation systems" were used in this study. However the technical specifications of each irrigation network could be summarized as following:

- *Solid-set Sprinkler Irrigation:*

Sprinklers set of 75mm with nozzles of 2.5mm x 3.5mm size having application rate of 7mm/hr, wetted radius of 6m was fixed at 12x12 m spacing. A tube well submersible pump of discharge 3.75 lps is used as supply source.

- *Surface Drip Irrigation Systems:*

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 25m length, built-in drippers with discharge of 4 lph/30cm spacing at 1.0 bar operating pressure. Total nine laterals of lateral spacing of 4 rows of wheat per lateral (0.8 m) had been investigated for the experimental achievements and all details about the experiment design as shown as in Fig. 1.

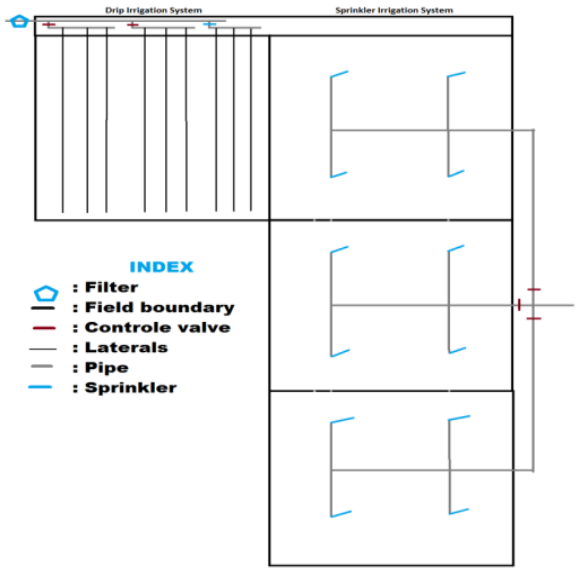

Fig-1 : Layout of Experiment Design

Data Recording:

Crop water requirement:

The amount of irrigation water was calculated on the basis of crop water requirement by the fallowing formula [10].

$$D = PE \times Pc \times kc \times IE. \quad (1)$$

Where,

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

Yield and yield attributes:

At harvest, a random sample of 1m length X 1m width were taken from each plot to determine grain, straw and biological yields was determined from the whole area of experimental unit and then converted to yield per hectare. Grain-straw ratio and water productivity were calculated with fallowing formula.

Grain-straw ratio = Grain yield (kg/ha) / Straw yield (kg/ha)

Water productivity = Grain yield (kg/ha) / Total water applied (cm)

RESULTS AND DISCUSSIONS

Data tabulated in Table (1) revealed that there was a significant effect of the applied irrigation systems on the wheat yields (straw and grains) and irrigation water saving. Regarding the wheat grain yield and 1000 grain wt. (test wt.), data indicated that in drip irrigation grain yield was 12.14% and test weight was 17.86% more than the sprinkler irrigated wheat. This may be due to effectiveness of drip irrigation system in conserving soil-moisture in the effective root zone which was continuously available throughout the growing period and result in less water stress in root zone of crop. However there was a slightly reduction of 2.08% in biological yield. This may be due to the wheat plants had exposed to higher water-stress during the growing stages.

Table-1: The yield attributes characters and water productivity of wheat crop under drip and sprinkler irrigation.

S. No.	Parameters	Irrigation Method	
		Drip irrigation	Sprinkler irrigation
1	Biological yield (q/ha)	85.32	87.10
2	Grain yield (q/ha)	42.95	38.30
3	Straw yield (q/ha)	42.37	48.80
4	1000 grain wt. (gm)	38.66	32.80
5	Grain-straw ratio	1.01	0.78
6	Total irrigation water applied (cm)	35.00	38.00
7	Water productivity (kg/ha-cm)	122.71	100.78

Data also revealed that water productivity of drip irrigated wheat was 21.76% more than the sprinkler irrigated wheat. This may be due to high overall irrigation efficiency of drip (80-90%) as comparison to sprinkler irrigation system which has (50-60%) [13].

CONCLUSIONS

Observed data and attributed evaluation and analysis processing towards the application priorities of drip irrigation, as an alternative system of sprinkler irrigation systems, may be an effective technique for rationalizing irrigation water and maximizing water use and increasing yield under drought conditions.

Using drip irrigation in wheat (GW-273) can save 8.57% of irrigation water and increased yield by 12.14% over sprinkler irrigation method.

In conclusion, results indicated that the alternative irrigation system (drip irrigation) can be applied effectively for irrigating intensive field crops, but more studies have to be conducted under similar field conditions.

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REFERENCES

[1] Alam, M., T. Trooien, S. Stone and Rogers D. (2000). Subsurafce drip irrigation for Alfalfa. Nat. Irrigation Sym., Nov. 14 – 16, Phonix, Az, USA, pp 373–378.
[2] Arafa Y.E.,Essam A.W., Hazem E.M. (2009).Maximizing Water Use Efficiency in Wheat Yields Based on Drip Irrigation Systems. Australian Journal of Basic and Applied Sciences, 3(2): 790-796.
[3] Camp, C.R., (1998). Subsurface drip irrigation: A review. Trans. ASAE, 41(5): 1353-1367.
[4] Camp, C.R., F.R. Lamm, R.G. Evans and C.J. Phene, (2000). Subsurface drip irrigation- Past, Present and Future. Nat. Irrigation Sym., Nov. 14 – 16, Phonix, Az, USA, 363–372.
[5] Chauhan, R.P.S., Yadav, B.S. (2012). Studies On Crop Yield Responses To Deficit Irrigation And Levels Of Nitrigen In Wheat, Water, Energy and Food Security: Call for Solutions, India Water Week 2012, New Delhi
[6] Hoff, H. (2004). Mainstreaming Climate Adaption into Watershed Management. Climate Protection Programme for Developing Countries. Indo-German Bilateral Project on Watershed Management, 151.
[7] International Grain Council . (2013). Market report on grain, GMR-435.2013.
[8] INCID. (1994). Drip Irrigation in India, Indian National Committee on Irrigation and Drainage, New Delhi.
[9] Kharrou, M.H., Salah, R., Ahmed, C., Benoit, D., Vincent, S., Michel, L., Lahcen, O., Lionel, J., (2011). Water use efficiency and yield of winter wheat under efferent irrigation regimes in a semi-arid region. Agri. Sciences Vol.2, No.3, 273-282.
[10] Mane, MS; Ayare, BL; Magar, SS. (2006). Principle of drip irrigation, Publ. Jain Brother, New Delhi. Pp 31.
[11] Rahman, G.A. (2009). Water Use Efficiency of Wheat under Drip Irrigation Systems. American-Eurasian J. Agric. & Environ. Sci., 5 (5): 664-670.
[12] Rosegrant, W.M. (1997). Water Resources in the Twenty-First Century: Challenges and Implications for Action, Food, Agriculture and the Environment Discussion Paper 20, International Food Policy Research Institute, Washington D.C., U.S.A.
[13] Sivanappan, R.K. (1998), "Irrigation Water Management for Sugarcane", in VSI, pp. II 100 – II 125.
[14] Suarez-Rey, E., C.Y. Choi, P.M. Waller and D.M. Kopec, (2000). Comparison of subsurface drip irrigation and sprinkler irrigation for Bermuda grass turf in Arizona. Trans. ASAE, 43(3): 631-640.