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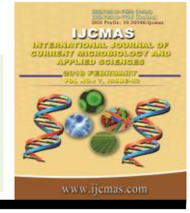

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On-Farm Drip Irrigation in Rice for Higher Productivity and Profitability in Haryana, India

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Micro irrigation systems endow lot of water saving for future crop and expand the land under cultivation with sustains the soil healthy for sustainable growth towards achieving growing food grain demand. Keeping this, the present on-farm trial was conducted in a farmer field of Gumthala Garhu village of Kurukshethra district, Haryana state. For assessment of rice yield, three different irrigation methods viz. drip, sprinkler and flood irrigation methods were adapted. The experiment was tested with PR 126 rice variety. The results revealed that rice grain yield (6950 kg ha^{-1}) was significantly increased by drip irrigation method compared to flood irrigation (6225 kg ha^{-1}) method. Sprinkler irrigation method gave a lower yield. Also, drip irrigation method of paddy cultivation was recorded considerable higher water use efficiency (17.1 kg ha mm^{-1}) followed by sprinkler method (11.5 kg ha mm^{-1}). Consistently, due to higher yield, higher net return was showed in drip irrigation method.

Introduction

Rice (*Oryza sativa* L.) is the most vital staple food crop in Asia and human consumption accounts for 85% of total production of rice and it ought to have a special status among cereals as world's most important crop (FAO, 2010). Given its burgeoning population growth, India should be producing 1.7 million t of additional rice every year to ensure national food security (Dass and Chandra, 2013). Consequently, there is a need to increase sustainably higher yields and productivity of rice cultivation, doing this to the extent possible with reduced inputs and with less exploitation of natural resources to feed the increasing global population. This is a challenge for rice-growing countries around the world.

For producing rice at present with traditional irrigation techniques, large quantities of water are being used to flood paddy fields with standing water 2-5 cm deep at the different stages of crop growth. Studies have indicated that 3.0 to 5.0 m^3 of water are often used to produce 1 kg of rice (Satyanarayana *et al.*, 2007), but this includes water applications which are clearly excessive. Water requirements for flooded rice production are now considered to average a little over 1.40 m^3 per kg of rice. This is about three times more than for growing wheat and maize (Riaz, 2001). This will inexorably affect farming system of irrigated regions in future, especially irrigated for rice production. Further, traditional rice production system not only leads to wastage of water but also causes environmental problems and reduces nutrient use efficiency. Hence, an attempt to increase water productivity either by reducing water consumption or by increasing the yields will automatically facilitate higher growth in agricultural production. Micro irrigation through the trickle supply of water drops and or sprinkler systems holds promise in this respect. Micro Irrigation System (MIS) coming strongly as effective system for irrigating the paddy crop with more efficient in water use as well as more environment friendly in operation and management. With MIS system we can move towards "more crop per drop" (Soman, 2012).

Studies of water usage of many field crops, such as grapes, cotton, and tomatoes, suggest that different modes of irrigation significantly affect crops growth and WUE, with higher water productivity and higher crop yield obtained under micro irrigation than under traditional irrigation (Malash *et al.,* 2008). In addition, there is little information regarding whether rice has higher grain yield and WUE under drip irrigation than under traditional irrigation, or whether rice cultivation with drip irrigation has superior grain production potential than that of existing rice water saving technologies.

On the other hand, conventional fertilization particularly on light soils may cause huge nutrient losses through leaching, percolation and volatilization. The greatest nitrogen loss in a rice field is in the range 20-45% through the process of volatilization and de-nitrification and 30-49% through leaching into ground water (Kyuma, 2004). Precision N management through fertigation with drip irrigation can reduce overall fertilizer application rates and minimize adverse environmental impact. Researchers have demonstrated drip-irrigated crop response to N fertilizer with higher water use efficiency (Hanson and May, 2004; Wang *et al.,* 2009). The limited information is available on use of drip irrigation on improvement of rice production and resource use efficiency. Taking these points into account an on farm trial was conducted to evaluate the effects of micro irrigation as compared with traditional flood irrigation on yield, water use efficiency and economics of rice.

Materials and Methods

The on farm trial was conducted in the farmer Sardar Karanjeet Singh field of Gumthala Garhu village of Kurukshethra district , Haryana state . The experimental site is situated of Latitude 30˚75'N and Longitude 76˚78'E at an altitude of 260 m above mean sea level (MSL). Soil type of the experimental field is clay loam. Monsoon starts at the end of June and extends upto September. The annual rainfall of the region is 720mm. average 81% of annual rainfall provides fair amount of water in the South West Monsoon. The total rain received during cropping period was 337 mm and effective rainfall is 167 mm. The rainfall distribution is depicted in Figure 1. The summer months from March to May are very hot and humid.

Irrigation treatments

Field experiment was adopted using PR 126 of rice as the test variety. In this study, three different irrigation systems were used. These are drip, sprinkler and traditional flood systems. The irrigation treatments were based on average water requirement of rice crop upon soil moisture condition. The drip irrigation was given through PVC pipe after filtering through the screen filter by 7.5 HP motor from the bore well. The pressure maintained in the system was 1.2 kg cm^{-2}. From the sub-main, in-line laterals were laid out of 16 mm at a spacing of 0.6 m with 2.4 lph discharge rate emitter position at a distance of 40 cm. A line source of sprinkler irrigation System was used for sprinkler irrigation. The sprinkler heads were located at 10 m intervals on the lateral pipe and total number of sprinkler was 56 with part cycle for one acre land area. The flood irrigation was maintained at 5.0 cm water depth.

The urea as nitrogen and muriate of potash (MOP) as potash source of fertilizers were applied through fertigation under drip and sprinkler systems whereas Single Super Phosphate (SSP) and Zinc fertilizers were applied through soil application during the sowing time. In flood irrigation method, all fertilizers had applied broadcasting; in which, half dose of N, full dose of P and K fertilizers were applied through basal application and remaining half dose of N fertilizers applied through top dressing. The fertigation details are given in Table 1.

Results and Discussion

Rice grain yield

According to the results of this on-farm experimental study, rice yields ranged from 4800 kg ha^{-1} to 6950 kg ha^{-1} under transplanted rice of different irrigation systems. As seen from Figure 2, each irrigation methods produced different rice yields. The drip irrigation method resulted in a higher grain yield than that of either the sprinkler or flood method. This yield diversity is statistically significant. Considering the maximum yields, drip irrigation produced 11.65% more grain yield as compared to flood irrigation method, and 44.79% more than the sprinkler method. Hence, drip irrigation resulted in not only higher grain yield but also substantial input source saving such water and nutrient. Drip irrigation is facilitating continuous availability of water to the plant roots vicinity and thus plant always be growing with optimum soil moisture and proper aeration in soil resulted in higher root growth and grain yield. These findings are consistent with the results reported by Yang *et al.,* (2004) indicating that intermittent irrigation and maintaining moist, mostly aerobic soils not only enhances yield characters but also the root system’s development and functioning. These results were in accordance with the study of Viraktamath (2006) and Soman (2012). Further, lower yield with sprinkler irrigation may be the impact of the sprinkler drops on the flower and the burning of the flowers and leaves by sunshine due to the lens effect resulted in low spikelets and eventually low yield. The same result is also corroborated with the finding of Kadiyala *et al.,* (2012).

Water use studies

The total water use and water use efficiencies under flood, drip and sprinkler methods of irrigation are presented in Table 2. The total water use inclusive of effective rainfall in flood irrigation of farmers practice was 587.4 mm whereas it was only 407.3 mm and 419 mm in drip and sprinkler irrigation methods, respectively.

This resulted in 30.7 and 28.7 per cent of water saving under drip and sprinkler methods, respectively as compared to flood practice. The drip irrigation methods used less water due to restriction of water loss through evaporation from large amount of ground, conveyance losses resulted in maximum water use by crops. Similar result of water saving under drip irrigation was pointed out by Veeraputhiran (2000).

Fig.1 Annual rainfall as received during the experimental period in 2017

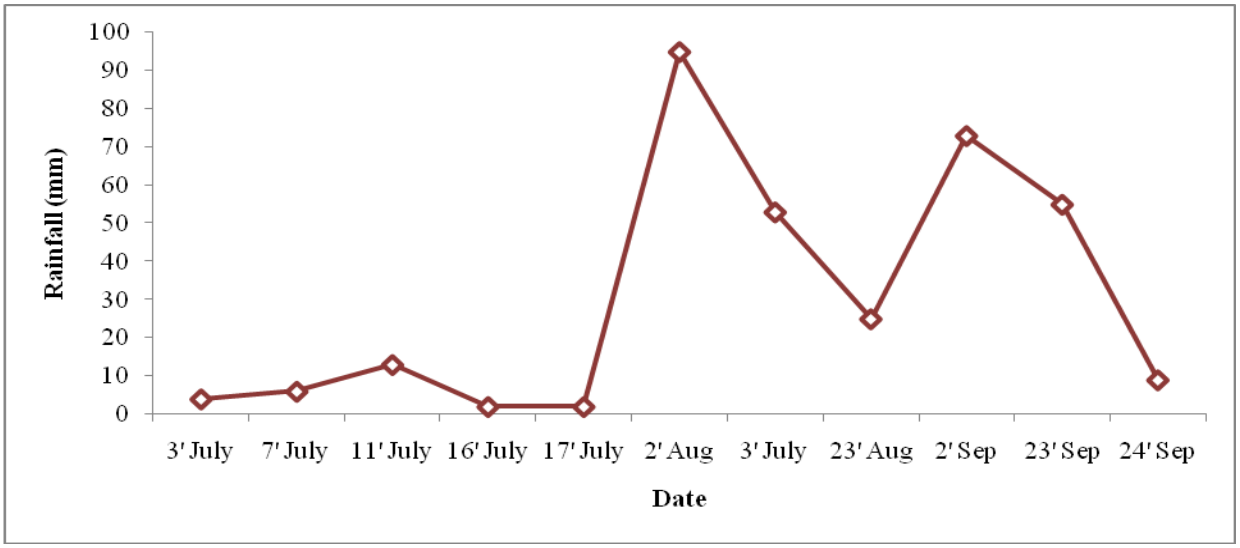

Fig.2 Grain yield of on-farm trial rice (kgha^{-1}) as influenced by different irrigation methods. Treatments means followed by common letter (s) are not significantly different among each other according to LSD test

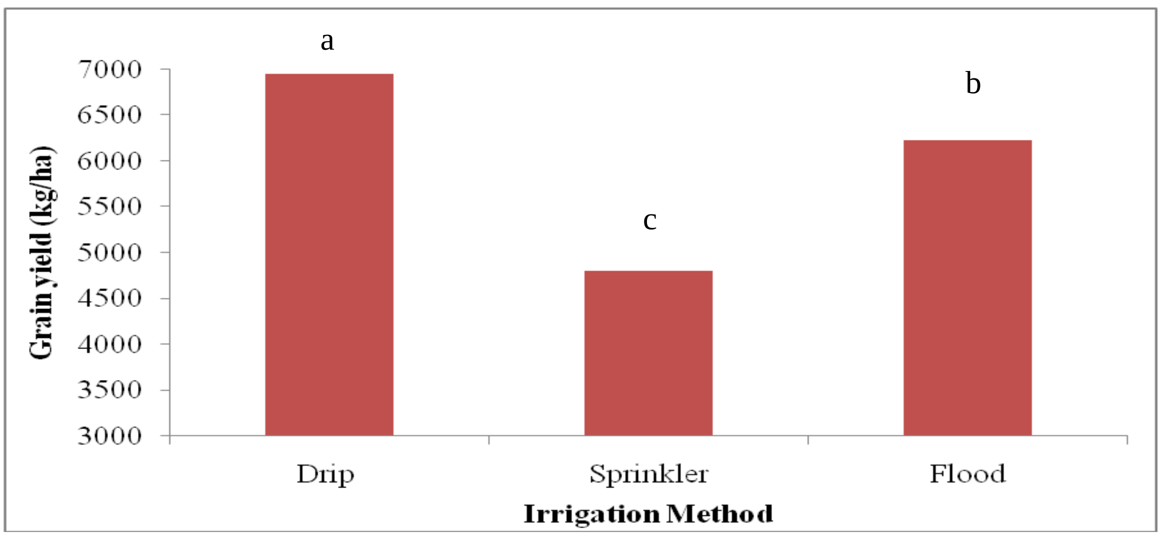

Table.1 Fertigation schedule followed for experimental transplanted rice under drip and sprinkler irrigation method

Schedule of Fertigation	Urea (kg)	SSP (kg)	MOP(kg)	Zn (kg)	Fertilizer rate per day
Basal (soil application)	0	150	0	10	3.5 kg urea/day
10-20 DAT (Fertigation)	35	0	0		2.08 kg urea/day
21-40 DAT (Fertigation)	52	0	0		650 gram urea/day
41-60 DAT (Fertigation)	13	0	15		750 gram urea/day
61-80 DAT (Fertigation)	0	0	10		500 gram urea/day

Table.2 Total water use and water use efficiency (WUE) (kg hamm^{-1}) under micro and flood irrigation methods

Treatments	Irrigation water applied (mm)	Effective rainfall (mm)	Total water used (mm)	Per cent saving of water over flood irrigation	WUE (kg ha mm^{-1})
Drip Irrigation	240.0	167.0	407.3	30.7	17.1
Sprinkler irrigation	252.0	167.0	419.0	28.7	11.5
Flood Irrigation	420.4	167.0	587.4	-	10.6

Table.3 Economic and monetary benefits of rice cultivation with micro irrigation systems over conventional system

Details	Transplanted Drip	Transplanted Sprinkler	Transplanted Flood
Total cost of drip/sprinkler system (Rs ha^{-1})	125000	100000	-
Subsidy given to the farmer (one hectare) 85% of total cost (Rs ha^{-1})	106250	85000	-
Farmers share (Rs.)	18750	15000	-
Cost of drip/sprinkler system for 7 year (2 crops/year) @ Rs.	1337.5	1072.5	-
Gross income/ha (Selling price @ Rs. 15.9 kg^{-1})	110505	76320	98977
Net income (Rs/ha^{-1})	84467	50572	74277
Incremental yield in drip/sprinklers/acre (in kg ha^{-1})	725	No	-
Net incremental income (Rs.)	11277	No	-

The paddy crop grown through drip irrigation was registered higher WUE (17.1 kg ha mm^{-1}) while low level of WUE (10.6 kg hamm^{-1}) was found in flood irrigation. The WUE of sprinkler method was 11.5 kg ha mm^{-1} in transplanted paddy crop. Adequate and timely availability of water, nutrients and their synergistic interaction had stimulated to record higher water use efficiency under drip fertigation (Veeraputhiran, 2000).

Monetary benefits

In the present study, the monetary benefits of rice crop under micro irrigation i.e. drip and sprinkler methods were compared with flood irrigation method. The annual cost of drip irrigation system was calculated with the assumption that the life micro irrigation system infrastructure would be 07 years with 07-10 per cent annual depreciation. The cost components considered included land preparation, seeds, fertilizer, labour, harvesting and threshing. Uniform cost values were considered for all irrigation method. The drip fertigation system has been found more profitable than sprinkler and flood irrigation due to higher yield. The finding of the study indicated that the higher net return (Rs.33787 per acre) was obtained under drip irrigation method followed by flood irrigation method of irrigation (Rs. 29711 per acre). The lowest net return (Rs.20229 per acre) was in sprinkler irrigation method (Table 3). It showed that drip irrigation produced 12% more net income than flood irrigation method, and 40% higher net income as compared to sprinkler irrigation system. Further, drip irrigation system proved 0.29 t higher incremental yield than any other method. Similarly, net increment income of drip irrigation system was Rs. 4511 over traditional flood irrigation method. Richakhanna (2013) reported that optimal water use can enhance returns with enhanced labour productivity and far higher net income than traditional methods for the cultivation of rice. These results were in agreement with the findings of Veeraputhiran *et al.,* (2002), Soman (2012) and Abdelraouf *et al.,* (2013).

The present study concluded that irrigation through drip system along with fertilizer applications recorded higher grain yield and WUE in transplanted paddy crop. However, these results should further be tested with advanced experimentation and evaluation because the implications of this work could be rather far-reaching. The evidence assembled and analyzed here suggests that transplanted rice cultivation with drip irrigation is a hopeful adaptation for reducing the rice-crop's demand for water and nutrient, which are increasingly demanded and costly, while at the same time it raises grain yield. Further, long term and multi-location trials will be needed to arrive at percentages of water and nutrient saving that are realizable under different and specific situation.

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