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Irrigation Management in Paddy based on Depleting Water Level below Soil Surface

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ABSTRACT
An on farm trial was conducted at farmer's field during Kharif season 2015 and 2016 to find out effects of applying alternate wetting and drying method of irrigation on no. of irrigations applied, water saving, yield, water input and field water use efficiency of Kharif paddy based on depleting water level in the perforated PVC water tube installed in field. The experiment was laid out in Randomized Block Design with 6 replications (no. of farmers) with three technological options(TO): TO-1= Continuous submergence of paddy field (Farmer's Practice), TO-2 and TO-3= application of irrigation water when water level in the perforated PVC water tube fell 5 and 15 cm below soil surface, respectively. Irrigation water was applied time to time when depleting water level in perforated PVC water tube reached to a certain level. Results of the study indicated that TO-3 saved three no. of irrigations and highest quantity of irrigation water as 1500 cubic meter per hectare than TO-1 (Farmer's Practice) whereas in TO-2, two no. of irrigations along with 1000 cubic meter per hectare irrigation water was saved. Yield and B: C ratio was observed at par in TO-3 as well as TO-2 as compared to farmer's practice during year 2015.In year 2016, result revealed that TO-3 and TO-2 produced again at par yield (3% increased yield) with B: C ratio 1:1.99 and 1:1.89, respectively as compared to B: C ratio of 1:1.79 in farmer's practice plots. Based on observations, it came out that continuous submergence of paddy field was not necessarily the only solution for optimum production. Findings of the study indicated that, number of irrigations as well as water use can be reduced by 30-50 percent with increased field water use efficiency by adopting this irrigation water management technology in paddy irrigation which will help farmers to cope up with water scarcity.
Key Words: *Alternate wet and dry method, Depleting water level, Field water use efficiency, Water tube*

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INTRODUCTION

Rice (*Oryza Sativa L.*) is one of the most important cereals of our country grown mostly during kharif season. It's cultivation has different water environment than all other crops. Since, water is becoming scarce; the per capita water availability is expected to decline day by day. Field water requirement of paddy crop includes evapotranspiration (ET) demand as well as unavoidable losses through seepage and percolation for continuously maintaining a saturated root zone during the crop growth period. In general practice, farmers often keep standing water in paddy field and they use field-to-field irrigation which leads to wasteful use of water in terms of surface runoff, seepage and percolation losses that accounts for about 50–80 percent of the total water input to the field [15]. So, scientists have searched and researched on different options for managing available water resources. Therefore, it becomes essential to develop and adopt such strategies and practices of on-farm water management that will promote to use water efficiently and reduce wasteful use of water.

One such practice to save water is the intermittent wetting and drying in which rice field is allowed for flooding or drying alternatively instead of continuous water submergence. In this practice, irrigation water is applied a few days after disappearance of ponded water when soil reaches a certain moisture level depending upon soil type, weather and crop growth stages and is known as alternate wet and dry irrigation (AWDI) [12]. This technology can reduce water use by up to 30% by reducing the number of irrigation [10]. It can enhance field level water productivity by minimizing seepage and percolation losses during the crop-growth periods. There are different forms of AWDI practiced in different parts of the world which have its impact on water saving and productivity [1, 9].

One method of implementing the concept of alternate wetting and drying in the farmer's field is by installing perforated water tube of plastic pipe or large diameter bamboo piece length to monitor the water depth on the paddy field which help in maintaining alternate flooding or drying according to depleting depth of ponded water. Farmers can monitor the water level in the root zone of paddy even when there is no standing water in the field [11]. According to Bouman et al [4], if field water level is not allowed to drop beyond 15 cm soil surface, this is safe limit of alternate wetting and drying. Reduction in yield was reported, if AWDI method practiced throughout the crop season as compared to when it was practiced in either vegetative or reproductive stage. So, such conditions/treatments have to be identified which will produce increased yield [3].

Hence, an on farm trial was conducted to find out effects of applying alternate wetting and drying method of irrigation on number of irrigations applied, water saving, yield, water input and field water use efficiency of paddy in Jehanabad district of Bihar (India) based on depleting water level in perforated PVC water tube installed in the field.

MATERIALS AND METHODS

An on farm trial was conducted at farmer's fields in Jehanabad district of Bihar which lies in NARP Zone – III B having sub- humid, sub-tropical agro ecological system. Soil of the district is old alluvial that vary from loamy to clayey with good workable tilth and paddy–wheat is major farming system followed in the area.The experimental area lies between 25^{o}to 25^{o} 15' North Latitude, 84^{o} 30' to 85^{o} 15' East Longitude and at an altitude of 54 meter from mean sea level. Maximum and minimum temperatureof the district is 47^{o} C during the summer month (June) and 5^{o} C in winter month (January) whereas maximum and minimum relative humidity is 99 and 26.66 percent, respectively. Mean annual rainfall of the district is 1074 mm out of which most of the rain occurs during Kharif season i.e. in the months of June to October.

The experiment was laid out with 6 replications (no. of farmers) each having 0.40 hectare area during Kharif season 2015 and 2016 to find out effects of applying alternate wetting and drying method of irrigation on no. of irrigations applied, water saving, yield, water input and field water use efficiency of Kharif paddy by monitoring field water level through perforated PVC water tube. The on farm trial was conducted with three technological options (TO) in which TO-1= Continuous submergence in paddy field (Farmer's Practice), TO-2 and TO-3 were application of irrigation water when water level in the perforated PVC water tube fell 5 cm and 15 cm below soil surface, respectively. Paddy var. Sahbhagi and R. Mahsoori-1 were transplanted in the two consecutive years, respectively in puddle bed condition for which the field was ploughed thrice and leveled properly by planking. The crop was raised with full agronomic practices including weed management in which paddy seed @ 25kg/ha was used and recommended dose of nutrient was applied through Urea, Di Ammonium Phosphate and Murat of Potash. The land was manually divided into a number of leveled rectangular check basins that were separated by low soil ridges and each plot was irrigated independently by turning a stream of water for which irrigation pump was used.

Alternate wetting and drying (AWD) method of irrigation was implemented in paddy field in which field water depth was monitored by installing a piece of PVC pipe (perforated) of 35 cm length and 20 cm diameter in each farmer's plot. In order to know the time of irrigation, water level was measured time to time in the PVC water tube installed in the plots of farmer [7] and next irrigation was applied when depleting water level inside the water pipe dropped to a certain level. Before installation, perforations of uniform diameter were made in the lower 20 cm length of PVC pipe at uniform interval all around by the help of hand drill whereas upper 15 cm portion of PVC pipe length was kept blunt. This perforated water tube was installed in paddy fields at a level place closer to the field bunds, keeping in view convenience in reading water level with the help of measuring tape so as to monitor ponding water level in water tube. Only perforated part of water tube (20 cm pipe length) was driven into the soil with the help of wooden hammer thus blunt portion (15 cm pipe length) remain up above the soil surface. After installation, the soil captured inside the water tube was removed so that bottom of the tube is visible. The perforation caused to flow the water in and out easily from water tube and due to large diameter of pipe, the readings of water level were easily visible. When water was available in the field, it came in the tube through perforations and water level in the PVC water tube was remaining the same as the water depth available in paddy field. Specification of perforated water tube: Total Height= 35 cm, Height of perforated portion= 20 cm, Diameter of water tube = 20 cm, Expected life of water pipe = 10 years, Total Cost= Rs. 320.

At about two weeks after transplanting of paddy, the field was left to dry out until the water level in the perforated water tube dropped by 5 cm and 15 cm below the soil surface, respectively in TO-2 and TO-3 and accordingly the field was irrigated again to a water depth of approximately 5 cm in these technological options whereas in farmer's practice plots, continuous submergence of paddy field has been maintained. This process of irrigation was repeated except during one week before and after flowering time, when a flooded water depth of about 2 cm was maintained in the field and irrigation was stopped 15 days before harvesting of crop. Water use in paddy cultivation was calculated as total water input in irrigation and rainfall from sowing to harvest whereas field water use efficiency (kg/ha-cm) was estimated as ratio of crop yield and amount of water used.

RESULTS AND DISCUSSIONS

This experiment was conducted for two consecutive years to find out impact of applying alternate wetting and drying method of irrigation on no. of irrigations applied, water saving, yield, water input and field water use efficiency of Kharif paddy by monitoring field water depth on the basis of depleting water level in perforated PVC water tube to 5 cm and 15 cm in two technological options. Since, rainfall has been main source of water during kharif season, monthly rainfall data for kharif season 2015 and 2016 were collected from District Agriculture Office, Jehanabad (Bihar) and have been presented in Table 1.

Table 1: Monthly rainfall occurred during Kharif Paddy season 2015 and 2016

Month	Normal Rainfall (cm)	Kharif 2015		Kharif 2016	
		Actual Rainfall (cm)	Deviation (%)	Actual Rainfall (cm)	Deviation (%)
June	12.41	12.95	4.35	7.70	-37.95
July	28.39	12.79	-54.94	29.20	2.85
August	32.60	18.57	-43.04	15.57	-52.24
September	17.09	7.64	-55.30	36.56	113.93
Kharif Total	**90.49**	**51.95**	**-42.59**	**89.03**	**-1.61**

Data on rainfall shown that in most of the months, the district has faced weak monsoon situation during both the years in which deviation of rainfall from normal was observed to be approximately 40 percent or more except a normal rainfall in June 2015 and July 2016 and surplus rain in September 2016.

Fig. 1: Perforated PVC water tube used for observation of water level by farmers

Fig. 2: PVC tube installed in the Paddy field showing same level inside and outside

Fig. 3: Depleting water level at 5 cm below soil surface: Time to irrigate the paddy field in TO2

Fig. 4: Water level at 15 cm below soil surface: Time to irrigate paddy field in TO3

Fig. 1 shown the prepared perforated PVC water tube, Fig.2 shown the PVC water tube installed in paddy field whereas Fig. 3 and Fig. 4 shown the depleting water level at 5 cm and 15 cm below soil surface i.e. time to irrigate the paddy field again in TO 2 and TO 3, respectively.

Table 2: Water saving, yield and economics of paddy irrigation based on water level in perforated PVC water tube during 2015 and 2016

Technological option	No. of Irrigations		Water saving (%)		Yield (q/ha)		Cost of cultivation (Rs./ha)		Gross return (Rs/ha)		Net return (Rs./ha)		B:C ratio	
	1st Yr	2nd Yr	1st Yr	2nd Yr	1st Yr	2nd Yr.	1st Yr	2nd Yr	1st Yr	2nd Yr	1st Yr	2nd Yr	1st Yr	2nd Yr
TO–1: Continuous submergence of paddy field (Farmer's Practice)	10	6	-	-	36.8	46.2	27000	38000	51888	67914	24888	29914	1.92	1.79
TO–2: Application of 5 cm irrigation water when water level in the perforated PVC pipe fell 5 cm below soil surface	8	4	20.0	30.0	37.2	47.6	27150	36990	52452	69972	25302	32982	1.93	1.89
TO–3: Application of 5 cm irrigation water when water level in the perforated PVC pipe fell 15 cm below soil surface	7	3	33.3	50.0	36.9	47.6	27150	35040	52029	69972	24879	34932	1.91	1.99

Data on number of irrigations applied, water saving, yield and economics of the On Farm Trial has been presented in Table-2, which depicted that in both the years, TO-3 saved 3 no. of irrigations with highest quantity of irrigation water as 1500 cubic meter per hectare than TO-1 (Farmer's Practice) whereas TO-2 saved 2 no. of irrigations and 1000 cubic meter per hectare irrigation water. Findings of the study indicated that, number of irrigations as well as water use can be reduced by 33.3-50 percent by applying alternate wetting and drying method of paddy irrigation based on depleting water level in perforated PVC water tube that is in accordance with Carrijo et al, [5] and TO-3 is recommended for better irrigation management practices in paddy crop for this region followed by TO-2. Hatta [8] reported that maintaining a very thin water layer at saturated soil condition or alternate wetting and drying in the paddy field can reduce about 40–70 percent irrigation water as compared to continuous shallow water ponding, without a significant yield loss. Similar findings were reported by Batta et al, [2] and Richards and Sander, [14].

Table-2 also inferred that yield and B: C ratio was at par in TO-3 as well as TO-2 as compared to farmer's practice plots during year 2015 whereas in year 2016, TO-3 as well as TO-2 again produced at par yield (3% increased yield as 1.4 q/ha) with B: C ratio of 1:1.99 and 1:1.89, respectively as compared to B: C ratio of 1:1.79 in farmer's practice plots. It is also obvious from table that gross return as well as net return under TO-3 and TO-2 were found at par in first year whereas in second year, an increase of Rs. 3068/- (10.25 %) and Rs. 5018/- (15.21 %) per hectare have been observed, respectively as compared to farmer practice (i.e. continuous submergence of paddy field).

Table 3 represents water input and field water use efficiency of paddy in different technological options which indicated that as the more water depletion below soil surface was allowed, water input reduced and field water use efficiency increased.

Table 3: Water input and field water use efficiency of Kharif Paddy

Technological options	Irrigation water use, cm		Rainfall occurred, cm		Total water input, cm		Yield, kg/ha		Field water use efficiency, Kg/ha-cm	
	1st Yr	2nd Yr	1st Yr	2nd Yr	1st Yr	2nd Yr	1st Yr	2nd Yr	1st Yr	2nd Yr
TO 1	50.00	30.00	39.0	89.03	89.00	119.03	3680.00	4620.00	41.35	38.81
TO 2	40.00	20.00	39.0	89.03	79.00	109.03	3720.00	4760.00	47.09	43.66
TO 3	35.00	15.00	39.0	89.03	74.00	104.03	3690.00	4760.00	49.86	45.76

Water input was maximum when continuous water submergence was maintained in the field (TO-1) and it was found minimum in case of TO-3 (when field water level dropped to 15 cm below soil surface). On the other hand, field water use efficiency was maximum under TO-3 and minimum in farmer's practice plots (TO-1) during both the years. Michael [13] reported same range of productivity of water for rice crop.

In both the years, farmers involved in the trial have actively participated with adaptation of the technology and based on observations, it came out that continuous submergence of paddy field was not necessarily the only solution for optimum production [6]. This technology of alternate wetting and drying irrigation (AWDI) method proved to be a water saving technology that farmers can apply to reduce their irrigation water consumption in paddy fields without reduction in yield.

CONCLUSIONS

Based on two years finding of the On Farm Trial, it is obvious that technology of applying alternate wetting and drying method of paddy irrigation based on depleting water level in perforated PVC water tube has been found successful and application of irrigation water when water level in the perforated PVC pipe fell 15 cm below soil surface (TO-3) performed best in terms of number of irrigations, water saving, yield, water input, field water use efficiency and economics followed by TO-2 (irrigation when water level fell by 5 cm below in the perforated PVC pipe. Thus, the results revealed that number of irrigations as well as water use can be reduced by 33.3-50 percent besides saving of irrigation cost, reduced water input and increased field water use efficiency under TO-3 which will help farmers to cope up with water scarcity and the same can be recommended for better irrigation management practices in paddy crop for this region followed by TO-2. This criterion will optimize the use of irrigation water and provide guidelines to the farmers for managing the irrigation water in less water availability conditions.

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