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Effect of Different Inflow Cutoff Ratio on Irrigation Water Saving, Yield, WUE and Economics of Wheat Cultivation

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ABSTRACT

A field experiment was undertaken at farmer's field to assess different inflow cut off ratio approach for effective management of irrigation water in wheat and to see its effect on water saving, yield, water use efficiency (WUE) as well as economics. The experiment was laid out with three technological options in which three irrigations were applied by making 5 m wide border strips. Inflow was cut off when advance (wetting) water front reached to 85 percent and 90 percent of border length, respectively in two different technological options whereas in farmer's practice plots, irrigation was allowed till water stagnation in the field for several hours. It was observed that the practice of water stagnation in the wheat field for several hour was not necessary for optimum production and water use can be lowered up to 22.93 per cent without yield reduction if irrigation is stopped at 90 percent cut off ratio whereas 27.10 per cent irrigation water saving with slightly reduced yield can be achieved by irrigation using 85 per cent cut off ratio. Therefore, the technological option with inflow cut off ratio of 90 per cent was found to be overall efficient followed by 85 percent cut off ratio and it can be successfully used for irrigation management in wheat crop for south Bihar region.

Keywords*:* Border irrigation, Cut off ratio, Technological options, Water saving, Water use efficiency

INTRODUCTION

Surface irrigation method is most widely used throughout the world (Trout, 1990). According to Clemmens *et al.* (2008), surface irrigation may become ineffective and inefficient due to field constraints like improper land slopes, shallow soil depth, poor water supplies as well as inappropriate design and layout or improper operation and management. Despite of progressive water shortage, farmers continue to use flooding irrigation. Poor management, uniformity and distribution of water have been reported as the most frequent problems of flooding irrigation, resulting in water logging, salinization and less water use efficiency (Ali and Mohammed, 2015) which also affects crop production. So, surface irrigation systems need special attention which is not only due to potential risk of higher water losses but also due to higher costs of replacing with alternative methods. Darouich *et al.* (2012) pointed out that adopting more advanced and costly irrigation technologies requires appropriate economic incentives, training of farmers and an institutional framework to support the sustainable use of water for irrigation. Wheat (*Triticum aestivum*) is one of the most important crops grown in India during *rabi* season and needs substantial amount of irrigation water for good growth and yield. Thus, effective management of irrigation water is to be adopted to enhance economic returns with limited use of water. Despite lot of emphasis being given to the adoption of sprinkler and micro irrigation system, majority of the irrigated area is still under different

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method of surface irrigation. According to Patnayak (2016), on-farm water management can reduce wasteful use of water and at the same time, it leads to increases in productivity. Zerihun *et al.* (2005) pointed out that most of area under wheat crop is irrigated by border. Therefore, evaluation of the surface irrigation methods is essential to identify suitable irrigation practices to improve the irrigation efficiency.

One of the most effective methods of water conservation under flood irrigation systems is minimizing the tail water or runoff water and deep percolation from irrigated fields. Cut off irrigation is one such irrigation water management practice that can be used to improve the irrigation efficiency by reducing the volume of irrigation water by eliminating water stagnation in the field (Parihar and Sandhu, 1987). Clemmens (1998) suggested distance based inflow cutoff criterion that offers advantages of operational convenience and a lower degree of sensitivity of design and management to inaccuracies in inflow measurements and also to non-uniformities in the distribution of inlet flow over the width of the border and the same is easily transferable to irrigators. It does not have a significant effect on the sensitivity of application efficiency to changes in border length and when near optimum management scenarios are achievable, border design and management can preferably be based on distance based cutoff criterion. Merriam and Killer (1980) tried quarter rule approach for minimizing deep percolation losses on the upper end and found that water should reach the lower end in one fourth of the time required for the desired depth of water to infiltrate in the soil. This concept may be achieved by changing the inflow rate and/or the length of the run (Trout, 1990 and Hart *et al.*, 1980). Valipour (2013) used different types of inflow regimes like continuous flow, cutback, fixed surge and variable surge for increasing irrigation efficiency in border irrigation. In traditional practice, high flow rate is used with cut back method in which the flow is completely cut off when the advance wetting front of the flow reached the end of the furrow. Cutback system can be feasible either in one stage or in multi stages (Walker and Skagerbre, 1987; Trout, 1990) but multi stage cutback system have operational difficulties. Therefore, assessment of cut off ratio is essential to identify suitable intervention for water saving. Recognizing the importance of good water management practices in agriculture, an On Farm Trial was undertaken at farmer's field in Jehanabad district of Bihar, India to study the effects of two different inflow cut off ratio in wheat irrigation and to see its effect on water saving, yield parameters, water use efficiency (WUE) as well as economics under limited water availability conditions of south Bihar. The main objective of this study was to evaluate the performance of border irrigation in comparison with the use of different inflow cut off ratio in wheat irrigation.

METHODOLOGY

The field study was carried at farmer's field in Jehanabad district of Bihar (India) during *rabi* season 2016-17 and 2017-18 which is situated at 25° to 25° 15' North Latitude, 84° 30' to 85° 15' East Longitude and at an altitude of 54 meter from mean sea level. It is located in the southern part of Bihar that lies in NARP Zone– III B with sub- humid, sub-tropical agro ecological system. The soil of the experimental area is leveled having a good tilth. The district's topography is alluvial plain and the soil is old alluvial varying from loamy to clayey. Paddy–Wheat is major farming system. Maximum and minimum temperature of the district is 47°C in summer month (June) and 5°C in winter month (January) whereas maximum and minimum relative humidity is 99 and 26.66 per cent, 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 and during rabi (winter) season, ground water is major source of irrigation and in this on farm trial also groundwater has been utilized for wheat irrigation due to non-availability of surface water during *rabi* season. The present experiment was laid out with wheat variety HD 2967 and HI 1563 in respective years in Randomized Block Design with 8 and 6 replications (no. of farmers) each of 0.40 ha. The trial was conducted with three different technological options: Farmer's Practice, Irrigation with inflow cut off ratio of 85 per cent and Irrigation with inflow cut off ratio of 90 per cent. The crop was raised with recommended agronomical practices and a head water channel was constructed at the upper part of the

field for water conveyance. The field was manually divided into a number of long parallel border strips of 5 meter width (Kumar, 2017) that run over the entire length of the field to utilize the available irrigation stream for rapid wetting up of strip through advancing water front. These border strips were separated by low height earthen subsidiary bunds made in the perpendicular direction of head water channel. Three irrigations were provided to the crop by means of irrigation stream (water pump) having discharge of 7.8 liters per second in different crop stages i.e. first irrigation at 21 days after sowing (Crown root initiation stage), second irrigation at 45 days after sowing (Late tillering stage) and third irrigation at 80 days after sowing (Milking stage). In order to identify cut off point within the border strip, a mark was made in the strips with locally available wooden nails for reaching 85 per cent and 90 per cent length in technological option TO2 and TO3, respectively. The flow in border strip was completely cutoff, when the advance wetting front of the flow reached to 85 per cent and 90 per cent of border length, respectively in TO2 and TO3 and stream was turned into next border strip, whereas in farmer's practice plots (TO1), irrigation was allowed till water stagnation in the field for several hours. According to Agarwal *et al.* (1971), cut off ratio varied from 65 to 90 per cent of border length for steam size 2.14 to 1.43 litre per second per meter width of border. During the study, quantity of water applied, water saving in irrigation from sowing to harvest as well as yield and economics of wheat cultivation was calculated beyond estimation of field water use efficiency (kg/ha-mm) as ratio of crop yield and amount of water used in irrigation.

RESULTS AND DISCUSSION

Irrigation water inflow was cutoff when advance water front covered, 85 per cent border length and 90 per cent border length in two different technological options, respectively in TO2 and TO3. After inflow cutoff (allowing water front to cover the specified border length), the remaining length of border automatically irrigated due to dampening effect of advance water front which has also resulted zero runoff and minimum deep percolation. Result of the on farm trial revealed from Table 1 that in the year 2016-17, TO3 (wheat irrigation with inflow cut off ratio of 90 percent) saved 481.6 cubic meter/ha (22.93 percent) irrigation water and produced highest yield as well as net return with B: C ratio of 2.09 (Table 2) as compared to 1.97 in farmers practice (TO1) whereas in 2017-18, again TO3 proved best technological option with a saving of 470.0 cubic meter/ha (22.38%) irrigation water and highest yield along with higher net return and B:C ratio of 1.97 as compared to 1.81 in farmers practice plots. However, Table 1 again depicted that TO2 shown better saving of irrigation water as 27.10 and 26.85 per cent, in respective years with reduced yield and net return (Table 2). Findings of the study indicated that practice of water stagnation in the wheat field for several hours has not been found necessary for optimum wheat production and irrigation water use was minimized without yield reduction when irrigation has been stopped at 90 per cent cut off ratio followed by irrigation using 85 per cent cut off ratio. Thus, TO3 (Irrigation using inflow cut off at 90%) has been recommended for wheat irrigation with

Table 1: Effect of different inflow cut off ratio on water saving, yield and water use efficiency of wheat

Technology option	Water applied (cubic meter/ha)		Water saving (cubic meter/ha)		Yield (kg/ha)		Water use efficiency (kg/ha-mm)	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
TO1: Irrigation till water stagnation in the field for several hours (Farmers Practice)	2100.0	2100.0	-	-	3940	3480	18.8	16.6
TO2: Irrigation with inflow cut off ratio 85 %	1531.0	1536.0	569.0 (27.10 %)	564.0 (26.85 %)	3900	3400	25.5	22.1
TO3: Irrigation with inflow cut off ratio 90 %	1618.4	1630.0	481.6 (22.93 %)	470.0 (22.38 %)	4000	3620	24.7	22.2
LSD (0.05)	56.4	54.5	8.6	7.5	9.9	21.5	0.62	0.52

Table 2: Economic impact of inflow cutoff ratio in wheat irrigation

Technology option	Cost of cultivation (Rs/ha)		Gross return (Rs/ha)		Net return (Rs/ha)		B:C ratio	
	1st year	2nd year	1st year	2nd year	1st year	2nd year	1st year	2nd year
TO1: Irrigation till water stagnation in the field for several hours (Farmers Practice)	32500	32600	64025	59160	31525	26560	1.97	1.81
TO2: Irrigation with inflow cut off ratio 85%	30815	31000	63375	57800	32560	26800	1.99	1.86
TO3: Irrigation with inflow cut off ratio 90%	31074	31200	65000	61540	33926	30340	2.09	1.97
LSD (0.05)	167.5	162.0	157.6	365.4	235.5	372.9	0.011	0.011

optimum yield and net return as well as comparable water saving observed in this study followed by TO2 (Irrigation using inflow cut off at 85%) in which slightly high water saving was recorded with reduced yield, net return and B: C ratio than TO3. Agarwal *et al.* (1971) reported water saving when cut off ratio approach implemented in border irrigation of wheat crop and the findings of this on farm trial were also supported by the work of Zerihun *et al.* (2005). Table 1 represented quantity of water applied and field water use efficiency of wheat in different technological options which indicated that as the less quantity of water was applied, field water use efficiency increased. It is obvious from table that field water use efficiencies for wheat crop in TO2 and TO3 were calculated to be 25.5 and 24.7 kg/ha-mm in year 2016-17 (1st year) whereas it's value were 22.1 and 22.2 kg/ha-mm in year 2017-18 (2nd year) of experiment and for farmer's practice plot, 18.8 and 16.6 kg/ha-mm, in respective years. Water use efficiency increased when less quantity of irrigation water was applied. Michael (1999) reported reduced (12.5 kg/ha-mm) productivity of water for wheat crop which was due to more water application. Singh *et al.* (2018) urged saving of water when concept of advance ratio was incorporated in the design process of border strip irrigation of wheat. Farmers of the district participated actively in this trial and based on observations, it came out that the technology of cut off ratio proved to be a water saving technology that farmers can apply to reduce their irrigation water consumption in wheat fields without reduction in yield.

CONCLUSION

Findings of the study indicated that practice of water stagnation in the wheat field for several hours has not been necessary for optimum wheat production and up to 22.93 per cent water saving was recorded without yield reduction when irrigation stopped at 90 percent cut off ratio in wheat border strips followed by irrigation using 85 per cent cut off ratio with 27.10 per cent water saving. It is obvious from the findings of the study that surface irrigation runoff can be reduced through cut off ratio approach and therefore suggested for better irrigation management practices in the district. It has been proved to be a water saving technology that farmers can apply to reduce quantity of irrigation water in wheat without reduction in yield. The adoption of this improved surface irrigation practice will help farmers in getting increased yield per unit use of irrigation water and thereby to lower the use of ground water in comparison to practice of water stagnation in the wheat field.

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