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Water Productivity and Hydraulic Parameters of Furrow Irrigated raised bed with variable Furrow Sections in Wheat Crop

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Abstract

Consumptive use, water use, hydraulic parameters and yield of furrow irrigated raised bed system (FIRBS) in wheat were studied under three moisture regimes viz. 40, 50 and 60% maximum allowable depletion (MAD) at sub treatment of 15cm, 20cm and 25cm furrow depth. FIRBS resulted in maximum yield obtained in (29.61q/ha) were produced under 20 cm furrow depth with 50% MAD. The seasonal consumptive use varied between 246.00 to 372.42 mm. In furrow irrigated raised bed system 20 cm furrow depth at 40% MAD treatment recorded the highest value (372.42 mm). In furrow irrigated raised bed system the maximum water use efficiency found in 9.50 kg ha^{-1} mm^{-1} in 20 cm furrow depth under 50% MAD. The result revealed that advance time and recession curve in furrow irrigated raised bed system 15 cm furrow depth, and 20 cm furrow depth more parallel then 25 cm furrow depth. The parallelism of curves shows uniform distribution of water.

Keywords: FIRBS, MAD, Hydraulic parameters, Moisture regime, Wheat.

Introduction

Water is one of the most important commodity for sustaining life and it is likely to become scarce in the coming future, due to its increasing demands continuously, increase in population rapidly, in crore an industrial sector and expansion in economy of the country. Water is becoming increasingly scarce due to growing demand in domestic purpose and industrial sectors therefore development of water saving irrigation technologies which require comparatively less irrigation input than the traditional irrigation method. A new method of wheat sowing in which wheat is sown on raised beds known as Furrow Irrigated Raised Bed system (FIRBS). This method is being followed in many wheat growing countries. Bed planting of wheat helps in saving of 25–30 % water and reducing costly herbicide application by mechanical weeding of grassy weeds Jat *et al*[1]. Furrow-irrigated, raised-bed system (FIRBS) of planting crops can be a viable technology in reducing losses. Its other advantages, as envisaged by Hobbs[2], are maximum harvesting and utilization under low rainfall, avoidance of temporary flooding, improved drainage under high-intensity rainfall, higher N-use efficiency and less lodging. In Mexico the farmers achieved 10% higher yield by adopting FIRBS Sayre[3]. Furrow Irrigated Raised Bed irrigation system consists of alternate furrows and flat beds in ridges.

The irrigation efficiency can be achieved comparatively better by adopting the bed and furrow irrigation technique for cultivation of wheat and other row crops, with many advantages over conventional method of irrigation including basin system of irrigation.

Materials and Methods

A fields experiments was carried out in the Research Farm of SVCAET & RS, IGKV, Raipur, CG during the rabi season of 2015-16 on clay soil. The bulk density of the soil was 1.48 g/cm^3, field capacity was 27%, permanent wilting point was 13.15% and the basic infiltration rate of the soil was 0.58-0.66 cm/hr. The water productivity and hydraulic parameters in wheat crop were studied in furrow irrigated raised bed with variable furrow sections under three moisture regimes, viz. Irrigation at 40, 50 and 60% MAD (Maximum Allowable Depletion). In this system, three different depth of furrow at (M_1)15, (M_2)20 and (M_3)25 cm were made and the four row of crops at 22.5 cm were planted on top of each bed (Figure-1). Strip plot design was adopted by considering the moisture depletion and method of furrow irrigation as treatments. Irrigation water was applied in furrows. These were compared with border irrigation method. The number of irrigations applied were: 8, 6 and 5 times corresponding 40, 50 and 60% MAD. The amount of irrigation water applied to the crop is given in Table-1.

Table-1
Irrigation water applied (cm) under different moisture regime

Moisture Regime (irrigation at)	15 cm furrow depth	20 cm furrow depth	25 cm furrow depth	Border system
40%	35.19	34.89	34.75	36.07
50%	27.07	27.82	26.42	28.07
60%	21.51	22.21	22.51	23.24

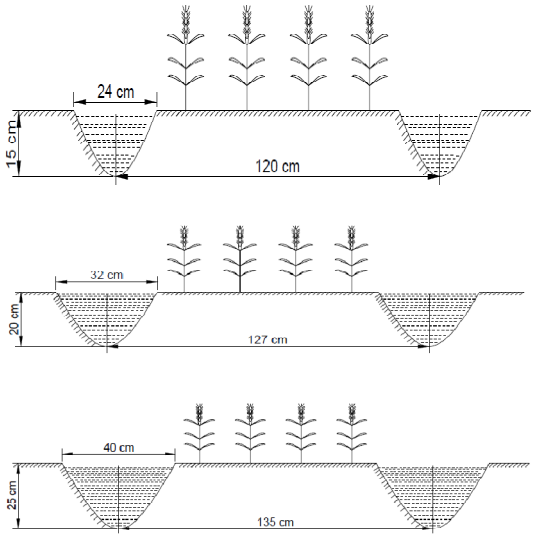

Figure-1
15, 20 and 25 cm depth of furrow irrigated raised bed system

Consumptive use: Consumptive use, often called evapotranspiration, is the amount of water used by the crop during its vegetative growth of a given area in transpiration and building up of plant tissues and evaporation from soil and plant surfaces. Since the difference between evapotranspiration and consumptive use is usually less than 1%. It is assumed equal to be ET.

Seasonal consumptive use (C_u) is calculate from the following relationship:

$$C_u = \sum_{K=1}^{N} (E_0 \times 0.8) + \sum_{l=1}^{n} \frac{M_1 i - M_2 i}{100} Ai.\, D_i + E_R$$

Where, C_u = seasonal consumptive use in mm; N = number of layers samples in root zoon depth D; M_1i = soil moisture percent at the time of first sampling in i^{th} layer; M_2i = Soil moisture percent at the time of second sampling in i^{th} layer; Ai = apparent specific gravity of the i^{th} layer of the soil; D_i = depth of i^{th} layer of the soil in mm; E_R = effective rainfall; N = time interval in days; E_0 = pan evaporation in mm from day of irrigation to day when soil samples were taken in wet soil.

Water Use Efficiency (WUE): Eventually water use efficiency of crop has is the ratio of grain yield (kg ha^{-1}) to the consumptive use (mm) of crop Michael[4].

$$WUE = \frac{\text{Grain yield(kg/ha)}}{\text{consumptive use(mm)}}$$

Hydraulic Parameters: The flow phenomenon in the furrow irrigation is unsteady open channel flow with decreasing discharge. The discharge at specific point changes with time due to independent intake behaviour of soil at the advancing end of water body, particular depth also changes with time and spaces Walker, *et al*[5].

Cross Section Area: The furrow cross section area was measured along the length of furrow by using graphical method before each irrigation. Relationship between furrow cross section area, wetted perimeter and top width with respect to depth of flow are shows in Table-2.

Table-2
Relationship between furrow cross section area, wetted perimeter and top width with respect to depth of flow

S.No.	Furrow Parameters	Treatment	I Irrigation	II Irrigation	III Irrigation
1	Cross section area (cm^2)	M_1	$A= 2.43h^{1.721}$	$A= 4.602h^{1.484}$	$A= 2.435h^{1.749}$
		M_2	$A= 4.982h^{1.518}$	$A= 1.084h^{1.876}$	$A= 6.908h^{1.236}$
		M_3	$A= 2.267h^{1.601}$	$A= 4.838h^{1.918}$	$A= 5.88h^{1.046}$
2	Wetted perimeter (cm)	M_1	$W= 4.936h^{0.769}$	$W= 6.865h^{0.660}$	$W= 5.119h^{0.784}$
		M_2	$W= 8.352h^{0.640}$	$W= 3.491h^{0.872}$	$W= 3.673h^{0.857}$
		M_3	$W= 5.349h^{0.765}$	$W= 5.746h^{0.749}$	$W= 4.72h^{0.812}$
3	Top width (cm)	M_1	$T= 4.231h^{0.686}$	$T= 5.300h^{0.607}$	$T= 4.662h^{0.660}$
		M_2	$T= 7.612h^{0.547}$	$T= 3.848h^{0.722}$	$T= 3.741h^{0.734}$
		M_3	$T= 4.750h^{0.687}$	$T= 4.264h^{0.728}$	$T= 4.706h^{0.704}$

Bottom Slope and Side Slope: The bottom slope of furrow was maintained 0.01 percent with the help of dumpy level and levelling staff and the side slope was 0.8H:1V maintained.

Depth of Flow of Water in furrow: The depth of flow of water was recorded at every irrigation. The relationship between depth of flow, cross section area, top width and wetted perimeter was worked out.

Time of Advance and Recession measurement: Advance and recession times were measured along the flow of water in both furrow and border. The stream 90 per cent cut off both in border and furrow. The advance and recession trajectory curve shows in Figure-2.

Results and Discussion

Yield: The maximum yield was 29.61q/ha was found in 20 cm furrow depth at 50% MAD followed by 15 cm furrow depth at 50% MAD in which 25.72q/ha yield was recorded. Comparatively in border irrigation method the highest yield was recorded 28.22q/ha under 50% MAD followed by 27.08q/ha recorded under 40% MAD (Table-3).

Consumptive use: The seasonal water supply is determined and evaluated by the seasonal water use efficiency. Consumptive use for furrow irrigated raised bed system and borders was estimated by moisture depletion method. The moisture depletion from sowing to harvesting was calculated. The moisture depletion for the days between irrigation applied and moisture samples taken was considered 0.8 of pan evaporation. The seasonal consumptive use varied between 246.00 to 372.42 mm (Table-4). In furrow irrigated raised bed system 20 cm furrow depth at 40% MAD treatment recorded the highest value (372.42 mm). In border irrigation method treatment at 40% MAD recorded highest value (288.00 mm).

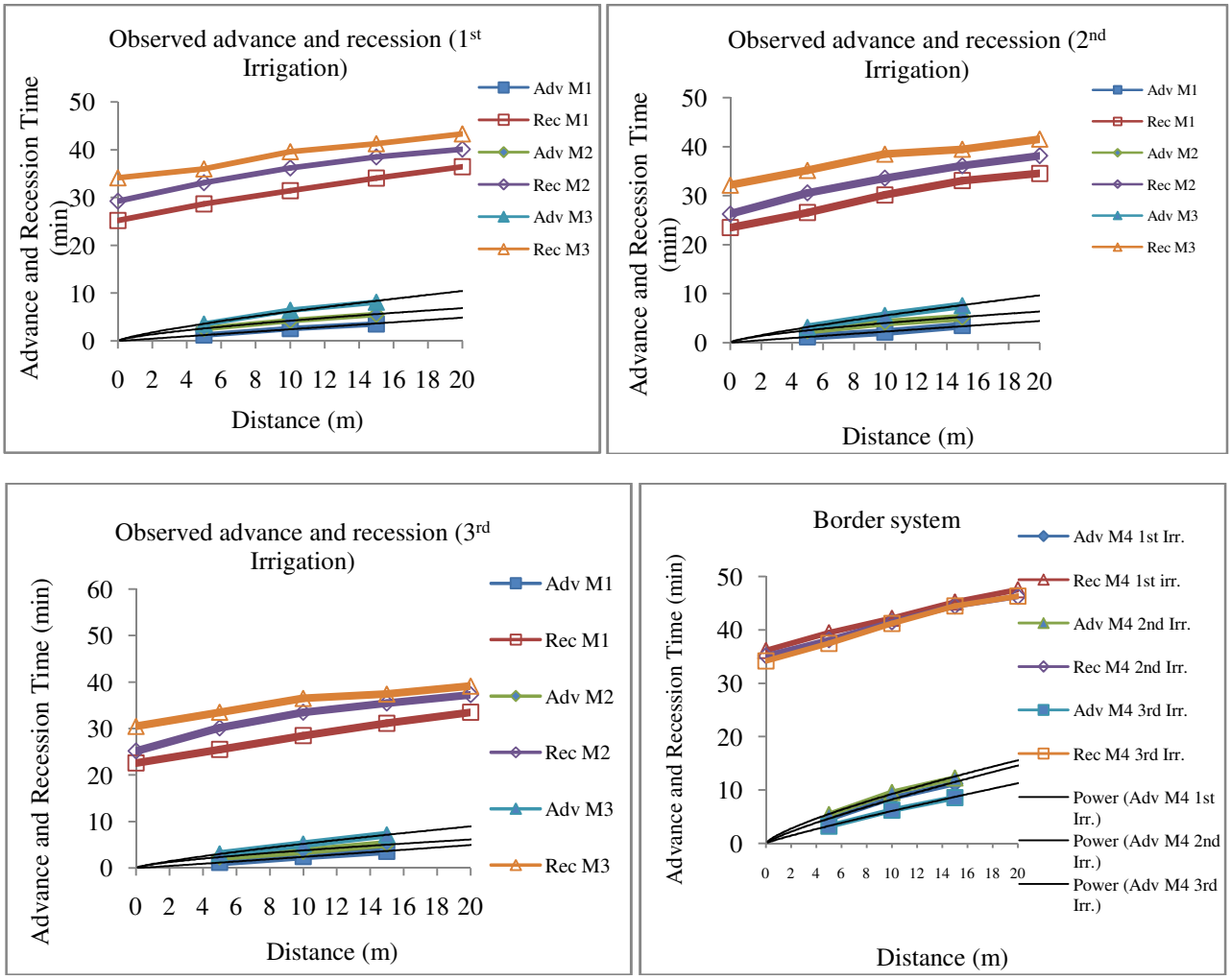

Figure-2
Advance and recession trajectory curve

Table-3
Two way table of grain yield (q/ha)

Treatment	M1	M2	M3	M4
40%	22.20	24.39	25.38	27.08
50%	25.72	29.61	27.14	28.22
60%	15.65	18.75	17.96	16.86

Table - 4
Seasonal consumptive use (mm) and water use efficiency (kg ha-1 mm-1) under different treatments

Treatment	15 cm furrow depth		20 cm furrow depth		25 cm furrow depth		Border system	
	SCU	WUE	SCU	WUE	SCU	WUE	SCU	WUE
40%	369.45	5.66	372.42	6.24	362.12	6.52	288	6.72
50%	278	8.48	296.4	9.5	283	9.17	284.9	8.98
60%	256.1	5.08	252.21	7.54	246	7.12	251.4	6.48

Water use efficiency: The water use efficiency varied from 5.08 to 9.50 kg ha^{-1} mm^{-1} for furrow irrigated raised bed system and similarly for border it varied from 6.48 to 8.98 kg ha^{-1} mm^{-1}. In furrow irrigated raised bed system the maximum water use efficiency found in 9.50 kg ha^{-1} mm^{-1} in 20 cm furrow depth under 50% MAD and minimum recorded in 15 cm furrow depth under 60% MAD (5.08 kg ha^{-1} mm^{-1}). In border irrigation Highest (8.98 kg ha^{-1} mm^{-1}) recorded in 50% MAD and minimum (6.48 kg ha^{-1} mm^{-1}) in 40% MAD. Likewise, in north-west India, Yadav *et al*[6]. recorded up to 36% saving of irrigation water in wheat.

Conclusion

On the basis of this study it can be concluded that the furrow irrigated raised bed system under 20 cm furrow depth at 50% maximum allowable depletion (MAD) in four row crops is comparatively better in terms of higher yield and water use efficiency. Similarly, in border irrigation system at 50% MAD found to be better in terms of higher yield as compared to other treatments of MAD.

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