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Research Article

Effect of Furrow Irrigated Raised Bed System and Irrigation Schedules on Soil Physical Properties of Wheat (*Triticum Aestivum* L.) in Western Uttar Pradesh

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Abstract

A field experiment was conducted during 2014-15 and 2015-16 at Meerut, Uttar Pradesh., India to study the effects of land configuration and irrigation schedules on soil physical properties such as bulk density, infiltration rate and soil penetration. In 0-15cm soil layer, bulk density least was under 90 cm bed, 4 rows ($B_{90–4}$) treatment (1.43 and1.41g $cm^{−3}$). The infiltration rate was recorded (10.2 and 11.2 cm hr^{-1}) under B_{90-4} (B_5) land configuration method which was closely followed by 90 cm bed, 3 rows B_{90-3} (9.7 and 10.5 cm hr^{-1}). The soil penetration resistance increase in depth up to 15-30 cm was observed with B_{90-4} (B_5) and B_{90-3} (B_4) land configuration recorded (2.38 and 2.35 Mpa) and (2.44 and 2.42 Mpa) significantly least soil penetration resistance as compared to 75 cm bed, 3 rows B_{75-3} furrow irrigated raised bed and conventional tillage. The highest organic carbon (0.53; 0.53 and 0.54; 0.54%) was recorded with 90 cm bed, 4 rows B_{90-4} and 4 cm irrigation at 0.8 IW/CPE. In furrow irrigated bed planting systems, 90 cm bed, 2 rows (B_{90-2}) land configuration and 4 cm irrigation at 0.8 IW/CPE registered significantly highest available nitrogen, available phosphorus and available potassium were under over rest of the treatments.

Keywords: Furrow irrigated raised bed system, land configuration, bulk density, infiltration rate

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Introduction

Wheat (*Triticum aestivum* L. emend. Fiori & Paol.) is very important and remunerative *rabi* crop of North India. It is the second most important cereal crop after rice, grown under diverse agro-climatic conditions. The irrigation efficiency of the border system has been found to be only 30-40% as compared to attainable level of 60-70%. The main reasons for its low productivity are poor crop establishment, improper scheduling of irrigation and deficient nutrition. Amongst the other agronomic practices proper crop establishment method may considerably increase the production of wheat to some extent. Ideal planting geometry is important for better and efficient utilization of plant growth resources get the optimum productivity of wheat. It is also well known fact that water management is one of the major factors responsible for achieving better harvest in crop production. Resource conservation technologies such as ridge and furrow and raised bed planting have been found very effective in saving water in crop production [1].Under semi-arid conditions water is the scarcest input which has considerable effects on the efficiency of other natural and applied inputs. The share of water to agriculture will further reduce to about 72 to 75% by 2050. About 75 to 85% water requirement of wheat in the north-western plain zone is met through irrigation. Bed planting system reduces herbicide dependence through intercultural tillage, and saves inputs like water and seed [2].Minimizing non-beneficial ET through efficient technologies and strategies will greatly enhance the water productivity. Both crop establishment method and irrigation schedule are major causes of growth and yield reduction in wheat, which also affect its soil properties.

Materials and Methods

The field experiment was established in 2014 at Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut research farm (29^0 04', N latitude and77^0 42' 'E longitude a height of 237m above mean sea level) U.P., India. The region has a semi-arid sub-tropical climate with an average annual temperature of 16.8^{0}C. The highest mean monthly temperature (38.9^{0}C) is recorded in May, and the lowest mean monthly temperature (4.5^{0}C) is recorded in January. The average annual rainfall is about 665 to 726 mm (constituting 44% of pan evaporation) of which about 80% is received during the monsoon period. The predominant soil at the experimental site is classified as Typic Ustochrept. Soil samples for 0–20 cm depth at the site were collected and tested prior to applying treatments and the basic properties were non-saline (EC 0.42 dS m^{-1}) but mild alkaline in reaction (pH 7.98). The soil initially had 4.1 g kg^{-1} of SOC and 1.29 g kg^{-1} of total N (TN), 1.23 g kg^{-1} of total phosphorus, 17.63 g kg^{-1} of total potassium, 224 mg kg^{-1} of available N, 4.0 mg kg^{-1} of available phosphorus, and 97 mg kg^{-1} of available potassium.

Detailed descriptions of crop establishment methods are necessary to compare the influence of land configuration practices on environmental performance. The treatments consisted of 6 crop establishment methods, viz sowing of wheat 75 cm bed, 2 rows ($B_{75–2}$); 75 cm bed, 3 rows ($B_{75–3}$) ; 90 cm bed, 2 rows ($B_{90–2}$) ; 90 cm bed, 3 rows ($B_{90–3}$), 90 cm bed, 4 rows ($B_{90–4}$); Flat planting, rows 22.5 cm apart as a horizontal factor with 3 irrigation schedule, viz 4 cm irrigation at IW/CPE 0.8**;** 5 cm irrigation at IW/CPE 1.0 ; 6 cm irrigation at IW/CPE 1.2 allotted to sub-plots in a split-plot design and replicated thrice. The gross and net plot sizes were 7.0 m×24.5 m and 6.0 m×3.5 m, respectively and treatments were superimposed in the same plot every year to study the cumulative effect of treatments.

Irrigation water was applied using polyvinyl chloride pipes of 15-cm diameter and the amount of water applied to each plot was measured using a water meter (Dasmesh Co., India). The quantity of water applied and the depth of irrigation was computed using the following equations:

$$\text{Quantity of water applied } (L) = F \times t \qquad (1)$$
$$\text{Depth of water applied (cm)} = L / A / 1000 \qquad (2)$$

Where F is flow rate (L/s), t is time (s) taken during each irrigation and A is area of the plot (m^2). Rainfall data was recorded using a rain gauge installed within the meteorological station. The total amount of water (input water) applied was computed as the sum of water received through irrigation (I) and rainfall (R).Water productivity (WP_{I+R}) (kg/m^3) was computed as follows [3]. Irrigation through tube-well of discharge 8 litre/second was given to each plot and measured with the help of Parshall flume.

$$WP_{I+R} = \text{Grain yield/(Irrigation water applied (I) + Rainfall received by the crop (R))} \qquad (3)$$

Soil moisture content was measure at seeding, and before and after each irrigation on the top of the ridge and furrow in furrow irrigated raised bed planting system and between the 2 rows in flat planting by using neutron moisture meter. Water saving (WS) was calculated as:

$$WS = (Q_F - Q_B)/Q_F \times 100,$$

Where Q_F and Q_B are quantity of water applied in flat planting and furrow irrigated raised bed planting system, respectively. The soil moisture data would be utilized to calculate the consumptive use.

The bulk density of the soil was determined by core method for depths of 0 - 15, 15 –30, 30-60 and 60-90 cm. An undisturbed soil cores were taken by hammering into the ground with the stainless steel cutter edge cylinders. Samples were oven-dried for 48 h at 105 ^{0}C, weighed and bulk density calculated according to [4].

Results and Discussion

Bulk density g cm^{-3}

Among different land configuration methods, flat planting have highest bulk density (1.52 and 1.51 g cm^{-3}) the bulk density of soil in the 0-15 cm depth and least was under B_{90-4} (B_5) treatment (1.43 and 1.41g cm^{-3}) during both the year of study. In upper layer, higher values of bulk density in flat planting compared to other land configuration were due to compaction soil surface as a result of application flood irrigation of crops (**Table 1)**. However each treatment was significantly differed in bulk density during experimentation. Whereas at 15-30 cm soil depth flat planted wheat was very close to 75 cm bed, 2 rows (B_{75-2}) land configuration during 2014-15 and 2015-16, respectively [5-8]. Also reported at lower depth most of the land configuration had similar trend in relation to bulk density and lowest was under 90 cm bed, 4 rows (B_{90-4}) treatment during both the year of study.

Infiltration rate cm h^{-1}

Land configuration 90 cm bed, 4 rows ($B_{90-4)}$ registered significantly the highest infiltration rate was recorded (10.2 and 11.2 cm hr^{-1}) showed that (**Table 1)** which was closely followed by 90 cm bed, 3 rows (B_{90-3}), (9.7 and 10.5 cm hr^{-1}). Treatment B_{90-4} was increased infiltration rate 72.9 and 77.8 % over the flat planting (B_6) during both the year of study [9,10] reported infiltration rate depending on soil texture, percentage of sand, silt and clay and number connectivity of surface vented macro-pores, dead root channels and organic matter present in soil.

Table 1 Effect of land configuration on bulk density and infiltration rate of soil

Treatment	Bulk density (g cm-3)									
	0-15 cm		15-30 cm		30-60 cm		60-90 cm		Infiltration rate (cm hr-1)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Land configuration										
75 cm bed, 2 rows	1.48	1.47	1.60	1.60	1.55	1.53	1.51	1.50	8.5	9.0
75 cm bed, 3 rows	1.46	1.44	1.57	1.55	1.55	1.52	1.51	1.49	8.8	9.3
90 cm bed, 2 rows	1.45	1.44	1.56	1.55	1.52	1.51	1.50	1.48	9.4	10.0
90 cm bed, 3 rows	1.44	1.42	1.54	1.52	1.52	1.50	1.50	1.47	9.7	10.5
90 cm bed, 4 rows	1.43	1.41	1.53	1.52	1.51	1.49	1.49	1.48	10.2	11.2
Flat planting	1.52	1.51	1.66	1.66	1.60	1.55	1.48	1.45	5.9	6.3
SEm(±)	0.02	0.02	0.014	0.017	0.004	0.005	0.002	0.002	0.4	0.37
C.D. (P=0.05)	*0.05*	*0.05*	*0.043*	*0.055*	*0.011*	0.017	*0.006*	*0.007*	*1.11*	1.17

Soil penetration resistance

The soil penetration resistance increase in depth up to 15-30 cm was observed with 90 cm bed, 4 rows (B_{90-4}) and 90 cm bed, 3 rows (B_{90-3}) land configuration recorded (2.38 and 2.35 Mpa) and (2.44 and 2.42) significantly least soil penetration resistance as compared to 75 cm bed, 3 rows (B_{75-3}) furrow irrigated raised bed and conventional tillage during both the years, respectively (**Table 2)**. In upper layer, higher values of penetration. The most likely reason for higher values of penetration resistance in conventional tillage treatment was the excessive use of tillage implements causing compaction in the plough layer. [7, 11] also justified the result obtained in similar way.

Table 2 Effect land configuration on soil penetration resistance of soil

Treatment	Soil Penetration Resistance (Mpa)					
	0–5 cm		5–15 cm		15–30cm	
Land configuration	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
75 cm bed, 2 rows	1.34	1.33	2.29	2.28	2.84	2.84
75 cm bed, 3 rows	1.28	1.26	2.23	2.21	2.61	2.60
90 cm bed, 2 rows	1.26	1.25	2.20	2.19	2.57	2.56
90 cm bed, 3 rows	1.18	1.16	2.07	2.05	2.44	2.42
90 cm bed, 4 rows	1.14	1.12	1.98	1.96	2.38	2.35
Flat planting	1.50	1.15	2.78	2.77	3.85	3.85
SEm(±)	0.02	0.02	0.04	0.03	0.03	0.02
C.D. (P=0.05)	0.05	0.06	0.08	0.10	0.09	0.08

Soil electric conductivity

After wheat harvest the data in respect to electric conductivity and pH of 0-15 cm soil layer are given in (**Table 3)**. The electric conductivity was recorded maximum 0.26 and 0.24 dSm^{-1} under flat planting (B_6) treatment and minimum values 0.21and 0.22 dSm^{-1} also obtained was under 90 cm bed, 4 rows (B_{90-4}) during 2014-15 and 2015-16, respectively [12,13].

Soil pH

Perusal of data presented in (Table 3) revealed that pH was registered lowest values (7.4 and 7.5) under 75 cm bed, 3 rows (B_{75-3}) and 90 cm bed, 4 rows (B_{90-4}) land configuration than rest treatments during both the year of study [13,14].

Table 3 Effect of land configuration on electrical conductivity and pH of soil

Treatment	EC (dSm^{-1})		pH	
	2014-15	2015-16	2014-15	2015-16
Land configuration				
75 cm bed, 2 rows	0.22	0.23	7.6	7.7
75 cm bed, 3 rows	0.22	0.22	7.4	7.4
90 cm bed, 2 rows	0.23	0.24	7.7	7.8
90 cm bed, 3 rows	0.23	0.23	7.6	7.6
90 cm bed, 4 rows	0.22	0.22	7.4	7.5
Flat planting	0.24	0.26	7.7	7.9
SEm(±)	*0.003*	0.003	-	-
C.D. (P=0.05)	NS	NS	-	-

Organic carbon

In general, the organic carbon was highest under B_{75-2} treatment (0.54 and0.55%) to all other treatments except 75 cm bed, 3 rows (B_{75-3}) treatment during both the year of study. Treatment flat planting (0.50 and 0.51%) had lowest values as compared to all the treatments. The organic carbon content in soil was non-significantly difference with irrigation schedules during experimentation. The maximum organic carbon content was obtained (0.54 and 0.54%) with 4 cm irrigation at 0.8 IW/CPE than followed by other irrigation schedules[15, 16]. during 2014-15 and 2015-16, respectively.

The soil organic carbon content in top soil 0-15 cm was increase due to furrow irrigated raised bed land configuration as compared to flat land configuration. It's because of localized deposition of more fertile top soil on raised beds under altered land configuration than flat planting.

Available nitrogen

It is evident from the data (**Table 4**) that significantly higher available nitrogen was recorded under 90 cm bed, 2 rows (B_{90-2}) (248.56 and 249.71 N Kg ha^{-1}) and 90 cm bed, 3 rows (B_{90-3}) (247.14 and 248 53N Kg ha^{-1}) remained statistically at par with it. The reduction in available nitrogen in soil under flat planting was 23.7 and 21.1 % compared to 90 cm bed, 2 rows (B_{90-2}), 90 cm bed, 4 rows (B_{90-3}), respectively. However, 90 cm bed, 2 rows (B_{90-2}), registered 13.4 and 11.3 % significant available nitrogen in soil status over flat planting during experimentation. The higher available nitrogen in soil in relation to irrigation schedule, treatment IW/CPE 0.8 (I_1) recorded statistically (247.14 and 248.35 N Kg ha^{-1}) higher available nitrogen rest of the treatments during experimentation. Treatment 6 cm irrigation at 1.2 IW/CPE recorded lowest available nitrogen in soil during both the year of study [15-17].

Available phosphorus

Land configuration did show significant difference in respect to available phosphorus in soil. The maximum available phosphorus in soil was in 90 cm bed, 2 rows (B_{90-2}) being at par with 90 cm bed, 3 rows (B_{90-3}) and 75 cm bed, 2 rows (B_{75-2}). The available phosphorus was higher with irrigation schedules IW/CPE 0.8 (I_1) treatment (247.17 and 248.62 kg ha^{-1}). Lowest available potassium was recorded 242.02 and 242.82 kg ha^{-1} with IW/CPE 1.2 (I_3) during both the years respectively [15-17].

Available potassium

Among different land configuration methods, higher available potassium was recorded (247.17 and 248.57 K kg ha^{-1}) with 90 cm bed, 2 rows (B_{90-2}) and 90 cm bed, 3 rows (B_{90-3}) (246.18 and 247.25 K Kg ha^{-1}) remained statistically at par with it. Among irrigation schedules 4 cm irrigation at 0.8 IW/CPE was highest (246.77 and 247.52 kg ha^{-1}) available potassium and lowest available potassium 242.02 and 243.11 kg ha^{-1} with IW/CPE 1.2 (I_3) during both the years respectively. However, treatment IW/CPE 0.8 of 4 cm irrigation contains higher amount of NPK status of soil due to less leaching loss of available nutrients. It's occurs due to less amount of water available and nutrient do not solubilized more amount. [15-18] also observed the similar trend and supported the justification.

Table 4 Effect of land configuration and irrigation schedules on organic carbon, available nitrogen, phosphorus and potassium in soil

Treatment	Organic carbon (%)		Available N (Kg ha^{-1})		Available P (Kg ha^{-1})		Available K (Kg ha^{-1})	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Land configuration								
75 cm bed, 2 rows	0.54	0.55	245.42	246.76	14.39	14.53	244.33	245.66
75 cm bed, 3 rows	0.54	0.54	244.27	245.88	14.21	14.29	243.00	243.91
90 cm bed, 2 rows	0.52	0.52	248.56	249.71	14.50	14.78	247.17	248.57
90 cm bed, 3 rows	0.53	0.54	247.14	248.53	14.31	14.54	246.18	247.25
90 cm bed, 4 rows	0.53	0.53	244.38	245.67	13.62	13.68	244.15	244.62
Flat planting	0.52	0.52	243.12	243.86	12.58	12.71	242.03	242.83
SEm(±)	0.01	0.01	0.41	0.34	0.17	0.23	0.39	0.37
C.D. (P=0.05)	NS	NS	1.28	1.06	0.52	0.74	1.21	1.17
Irrigation schedules								
4 cm irrigation at IW/CPE 0.8	0.54	0.54	247.14	248.35	14.79	15.27	246.77	247.52
5 cm irrigation at IW/CPE 1.0	0.53	0.53	245.32	246.54	13.92	14.07	244.85	245.93
6 cm irrigation at IW/CPE 1.2	0.52	0.52	244.00	245.31	13.10	13.93	242.02	243.11
SEm(±)	0.01	0.01	0.26	0.26	0.23	0.26	0.24	0.26
C.D. (P=0.05)	NS	NS	0.77	0.76	NS	NS	NS	NS

Interaction

Available Interaction effect between irrigation schedules and land configuration in respect of available nitrogen was significant (Table 4). Maximum amount of available nitrogen in soil in IW/CPE0.8 (I_1) with B_{90-2}(B_3) land configuration during both years.

Conclusion

The land configuration B_{90-4}(B_5) recorded minimum bulk density and soil penetration resistance under 0-15 cm soil depth. Water intake rate also increased significantly 28% over flat planting. In addition, FIRB encouraged roots to penetration deeper in the soils. Keeping in view the above points, a study was conducted to compare furrow irrigated raised bed planting system in different bed size configurations and rows planted on the top of the bed with flat planting by including suitable irrigation schedules. Different land configurations were assessed for soil physical properties and soil fertility.

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References

[1] Gupta, R. K., and Zaidi, P. H., 2004. Potential of resource conservation technologies in enhancing use-efficiency of groundwater resources in the Indo-Gangetic Plains. (In) Groundwater Use in North-west India. Workshop papers. Abrol I P, Sharma B R and Sekhon G S (Eds). Centre for Advancement of Sustainable Agriculture (CASA), New Delhi.

[2] Fahong,W., Xuqing,W. and Sayre, K. 2004. Comparison of conventional, flood irrigated, flat planting with furrow irrigated, raised bedplanting for winter in China. 87: 35-42.

[3] Humphreys E, Kukal S S, Amanpreet Kaur, Thaman S, Yadav S, Yadvinder Singh, Balwinder Singh, Timsina J, Dhillon S S, Prashar A and Smith D J. 2008. Permanent beds for rice-wheat in Punjab,India. Part 2:water

balance and soil water dynamics. (In) Permanent Beds and Rice-residue Management for Ricewheat Systems in the Indo-Gangetic Plain. Humphreys E and Roth C H (Eds).

[4] Blake G R and Hartge K H. 1986. Bulk density. (In) Methods of Soil Analysis. Part I. Physical and Mineralogical Methods, second ed, pp 363–82.

[5] Klute A (Ed), Agronomy Monograph No. 9, ASA and SSSA, Madison, WI.

[6] Aggarwal, P. and Goswami, B.2003. Bed planting system for increasing water-use efficiency of wheat (Triticum aestivum) grown on Inceptisol (TypicUstochrept). Indian Journal of Agricultural Sciences; 73 (8):422-425.

[7] Govaerts, B., Sayre, K.D., Ceballos-Ramirez, J.M., Luna-Guido, M.L., Limon-Ortega, A., Deckers, J. and Dendooven, L. 2006. Conventionally tilled and permanent raised beds with different crop residue management: Effects on soil C and N dynamics. Plant & Soil 280 (1&2): 143-155.

[8] Naresh, R.K., Singh, S.P. and Kumar, Vineet. 2013a. Crop establishment, tillage and water management technologies on crop and water productivity in rice-wheat cropping system of North West India. International Journal of Sciences of Life Sciences Biotechnology and Pharma Research; Pp 1-12.

[9] Jat, L. N. and Singh, S. M. 2003.Varietal suitability, productivity and profitability of wheat (Triticum species) intercrops and relay cropping under furrow-irrigated raised bed system. Indian Journal of Agricultural Sciences; 73 (4):187-190.

[10] Ram, Hari., Dadhwal, Vikas., Vashist, Krishan, Kumar., Kaur, Harinderjit., 2013 Grain yield and water use efficiency of wheat (Triticum aestivum L.) in relation to irrigation levels and rice straw mulchingin North West India Agricultural Water Management 128 92– 101

[11] Gathala, M.K., Ladha, J.K., Saharawat, Y.S., Kumar, V., Kumar, V. and Sharma, P.K., 2011. Effect of tillage and crop establishment methods on physical properties of a medium-textured soil under a seven-year rice–wheat rotation. Soil Science Society of America Journal 75: 1851–1862.

[12] Jat, M.L.,Gathala, M.K., Saharawatd,Y.S., Tetarwale,J.P., Gupta, Raj., Singh, Yadvinder. 2013.Double no-till and permanent raised beds in maize–wheat rotation ofnorth-western Indo-Gangetic plains of India: Effects on crop yields,water productivity, profitability and soil physical properties. Field Crops Research 149: 291–299

[13] Kumar, Ashok., Sharma, K. D., Yadav, Ashok.2010. Enhancing yield and water productivity of wheat (Triticum aestivum) through furrow irrigated raised bed system in the Indo-Gangetic Plains of India. Indian Journal of Agricultural Sciences; 80 (3):198-202.

[14] Ghane, E.Feizi, M. Mostafazadeh-Fard, B.Landi, E. 2009. Water productivity of winter wheat in different irrigation/planting methods using saline irrigation water. International Journal of Agriculture and Biology; 11 (2):131-137.

[15] Idnani, L.K. and Kumar, Ashok. 2013. Performance of wheat (Triticum aestivum L.) under different irrigation schedules and sowing methods. Indian Journal of Agricultural Sciences 83 (1): 37–40.

[16] Naresh, R.K., Rathore, R.S., Yadav, R.B., Singh, S.P., Misra, A.K., Kumar, V., Kumar, N. and. Gupta, Raj K. 2014. Effect of precision land levelling and permanent raised bed planting on soil properties, input use efficiency, productivity and profitability under maize (Zea mays) – wheat (Triticum aestivum L.) cropping system. African Journal of Agriculture Research; 9 (36): 2781-2789.

[17] Ramesh, P., Panwar, N. R., Singh, A. B. and Ramana, S. (2008) Effect of organic manure on productivity, soil fertility and economics of soybean (Glycine max)-Wheat (Triticum aestivum) cropping system under organic farming in Vertisols. Indian J. of Agric. Sci. 78 (12) : 1033-1037.

[18] Jat, M. L., Gupta, Raj.,Saharawat, Y. S., Khosla, Raj. 2011. Layering Precision Land Leveling and Furrow Irrigated Raised Bed Planting: Productivity and Input Use Efficiency of Irrigated Bread Wheat in Indo-Gangetic Plains.American Journal of Plant Sciences, 2, 578-588

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