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Effect of rice stubble and irrigation scheduling on water use efficiency (WUE) and water productivity of wheat

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Abstract
A field experiment in split plot design with 3 replications was conducted during the *rabi* season of 2021-22 at Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar to investigate the "Effect of rice stubble and irrigation scheduling on WUE and water productivity of wheat**".** The treatments included 5 irrigation levels: I_1 (Irrigation at the CRI stage), I_2 (Irrigation at the CRI + boot stage), I_3(Irrigation at the CRI + milk stage), I_4(Irrigation at the CRI + late jointing + milk stage) and I_5 (Irrigation at the CRI + maximum tillering + flowering + dough stage). 3 replications R_1 (rice stubbles cut at a height of 5 cm), R_2 (rice stubbles cut at a height of 20 cm) and R_3 (rice stubbles cut at a height of 35 cm). HD-2733 was the test cultivar. The soil texture of the experimental plot was sandy loam, with an alkaline reaction (pH 8.2) and low levels of available N (201.2 kg/ha), P_2O_5 (17.18 kg/ha), and K_2O (120.05 kg/ha). I_1 recorded the highest WUE and water productivity, which was highly significant and superior to I_2, I_3, I_4, and I_5. WUE and water productivity were all significantly higher with R_2 treatment of rice stubbles but statistically at par with R_1. Moisture content in the soil did not change significantly after 5 days between irrigations due to rice stubbles.

Keywords: Rice stubble, irrigation scheduling, water use efficiency, wheat

1. Introduction
Wheat is not only a major food source, but it is also an important crop for national food security, as it significantly contributes to food grain buffer stock. It plays an important role in ensuring national food grain adequacy, which has stabilised the country's food grain production at increasing levels. After rice, wheat is India's second most important food crop, covering 31.4 Mha with a production of 107.6 mmt and a productivity of 3.42 tha^{-1} (Department of Agriculture, 2019-20) [5]. In many parts of the world where rainfall is insufficient to meet crop demand, water has always been the primary limiting factor for crop production. Because of the rising competition for insufficient water resources all over the world, as well as the progressively rising demand for agricultural commodities, there has never been a better time to improve agricultural water use's effectiveness and productivity. Agriculture productivity is critical and water productivity serves as a key indicator in agriculture for assessing the impact of irrigation scheduling decisions on water management. Water productivity can be used to quantify the impact of irrigation scheduling decisions.

Irrigation is one of the most important and costly inputs directly impacting wheat growth and yield, when applied at the right time and in the right quantity, irrigation can significantly increase yield by creating a favourable soil moisture regime. The degree, duration and timing of the imposed soil-moisture deficit under limited irrigation determine the extent of grain yield reduction. The procedure for determining irrigation scheduling refers when and what amount of water should be applied per irrigation. Proper scheduling of irrigation is critical to maximizing the efficiency of water, energy, and other production inputs. Three significant factors influence scheduling of irrigation: (a) Crop water requirements; (b) Irrigation water availability; and (c) Water in the root system storage capacity. Crop water requirements are crucial for determining the timing of irrigation throughout the crop-growing season in irrigation projects.

Currently, crop residue burning is a major issue in India. Rice stubble or straw burning is a widespread issue in North India, causing severe pollution levels in Delhi and its surrounding areas. The nutrients in the stubble are destroyed during the burning process. As a result, proper crop residue management is essential. The removal of these crop residues reduces soil fertility and thus crop production. Most crop straw or stubble contains approximately 35%, 10%, and 80% of total N, P, and K respectively taken up by plants (Barnard and Kristofferson, 1985) [4]. According to the Department of Agriculture, Punjab government, less than 1% of farmers incorporate crop stubble because it requires more tillage operations. Cultivation on rice stubble will allow farmers to plan water rotation between fields, thereby minimizing crop water stress. Cutting rice stubble at various heights allows the remaining crop residues on the field to help replenish soil moisture. The current study aims to observe irrigation treatments at various stages of wheat growth.

2. Materials and Methods

During the Rabi season, an experimental trial was carried out at Dr. Rajendra Prasad Central Agricultural University's research farm at Pusa (Samastipur), Bihar to investigate the effect of rice stubble and irrigation scheduling on WUE and water productivity of wheat**.** The research field is located on the Burhi Gandak River's southern bank. The research field was connected to the main irrigation channel, which, in turn, was linked to the farm tube well to ensure consistent and timely irrigation. Throughout the study, drainage system was in place to remove excess water. The trial was carried out in a calcareous sandy loam soil, classified under the soil order entisol. The soil testing results indicated an alkaline type of soil reaction (8.28) with lower values of OC (0.42%), N (201.2 kg/ha), P_2O_5 (17.18 kg/ha) and K_2O (120.05 kg/ha). The experiment was carried out in split-plot design (SPD) with 3 replications. It consisted of 5 main plots and 3 sub-plots *viz*., I_1(one irrigation at CRI Stage), I_2 (two irrigation at CRI + Booting Stage), I_3 (two irrigation at CRI + Milky Stage), I_4 (three irrigation at CRI + Late Jointing Stage + Milky Stage), I_5 (four irrigation at CRI + Maximum tillering + Flowering + Dough Stage) and sub-plot consist of R_1(rice stubbles cut at height 5 cm), R_2(rice stubbles cut at height 20 cm) and R_3 (Rice stubbles cut at height 35 cm). The variety used for wheat was HD-2733. Recommended dose of fertilizer (RDF) of wheat was 120:60:40 kg/ha N: P: K respectively. The spacing was maintained at 20 cm (RxR). Line sowing was done by manual broadcasting followed by mixing with a rotavator according to the treatment. Wheat was sown on 2nd December 2021. Nitrogen (N) dose was applied in two splits; half at planting time as basal and the other remaining half at two days later as top dressing. The entire amount of P and K was applied as basal at the time of sowing. Pre-sowing irrigation was applied for both seasons during 2021-2022. Common irrigation as per crop needs was applied based on moisture requirement status and crop development stages. The other management practices were adopted as per package of practices. Rice stubbles were cut at different heights *i.e*. 5, 20 and 35 cm from 25th to 30th November, 2021. During the trial, meteorological data were normal for crop growth. Observations on the WUE and water productivity data were assessed. The statistical analysis was carried out as per Gomez and Gomez (1984) [6]. Each irrigation applied 6 cm of water to the field. Treatment I_1 received (6 cm irrigation + 2.94 cm rain = 8.94 cm), I_2 (12 cm irrigation + 2.94 cm rain = 14.94 cm), I_3 (18 cm irrigation + 2.94 cm rain =14.94 cm), I_4 (18 cm irrigation + 2.94 cm rain =20.94 cm) and I_5 (24 cm irrigation + 2.94 cm rain = 26.94 cm).

2.1 Water Use Efficiency (WUE)

It denotes the amount of marketable product (grain) obtained per unit of crop water applied. It is calculated by using the formula below:-

$$\text{WUE}\left(\frac{\text{kg}}{\text{ha}\cdot\text{cm}}\right) = \frac{\text{Yeild}\left(\frac{\text{kg}}{\text{ha}}\right)}{\text{Water requirment(cm)}}$$

2.2 Water productivity (₹/m^3)

Water productivity was determined and expressed in m^3 for each irrigation treatment. The following formula is used to calculate water productivity:-

$$\text{Water productivity} = \frac{\text{Net Return}\left(\frac{₹}{\text{ha}}\right)}{\text{Total water consumed in }\frac{\text{m}^3}{\text{ha}} + \text{Effective rainfall}}$$

3. Results and Discussion

3.1 Soil moisture Content

Soil moisture content before and after irrigation at 5-day interval up to second irrigation, depending upon the growth stages of crop in different irrigation level and rice stubble height is presented in table 1. The treatment I_5 showed highest soil moisture 5-days after each of the three irrigations followed by I_4. In the case of replication, R_3 showed highest soil moisture both before (24.79%) and after (26.55%) irrigation. Hence, it can be concluded that three irrigation in wheat at CRI + maximum tillering + flowering + dough stages retains maximum moisture in soil.

Table 1: Moisture Content in soil after irrigation at 5 Day interval up to 2nd irrigation by TDR Method

Treatments	Moisture (%) before irrigation			Moisture (%) after irrigation		
Irrigation Scheduling(I)						
I_1- Irrigation at CRI Stage	24.23			24.69		
I_2 –Irrigation at CRI + Boot Stage	24.41			25.43		
I_3–Irrigation at CRI + Milk Stage	24.47			25.83		
I_4–Irrigation at CRI + Late Jointing + Milk Stage	24.51	25.10		26.00	26.50	
I_5–Irrigation at CRI + Maximum Tillering + Flowering + Dough Stage	24.60	24.75	24.84	27.05	27.55	28.10
Rice stubbles(R)						
R_1- Rice stubble cut at 5 cm height	24.27			25.40		
R_2- Rice stubble cut at 20 cm height	24.54			26.10		
R_3- Rice stubble cut at 35 cm height	24.79			26.55		

3.2 Effect of irrigation scheduling on WUE

Table 2 and Fig.1 summarize and graphically present the mean data containing WUE and water productivity. Irrigation scheduling had a significant impact on WUE. However, the maximum value of WUE was recorded at I_1, which was irrigated at the CRI stage (324.26 kg/ha-cm). This was significantly superior to I_5, which was irrigated at the CRI + maximum tillering + flowering + dough stage (148.48 kg/ha-cm), I_2, which was irrigated at the CRI + Boot stage (217.39 kg/ha-cm), I_3 which was irrigated at the CRI + milk stage (226.54 kg/ha-cm) and I_4. *i.e.* irrigation at CRI + late jointing stage + milk stage (187.10 kg/ha). It is significantly superior to all other treatments. This might be due the fact that under lower irrigation level *i.e*. at I_1, water was used only once. The increase in yield was relatively lesser than increase in water requirement, which consequently decreased WUE under higher number of irrigations. WUE decreased with increasing the irrigation levels. These findings are consistent with those of Kumar and Prasad (1986) [10], Lal (1984) [11], Saren *et al.* (2004) [14] and Bandopadhyay and Mallick (2003) [3] and Kumar and Kumar (2012) [9].

3.3 Effect of rice stubbles on WUE

Citation of data in table 2 regarding WUE revealed that rice stubbles cut at different height treatments showed variation and exerted significant effect on WUE (234.78kg/ha-cm) was maximum at R_2 (Rice Stubble cut at height 20 cm**)**, which was significantly superior to R_3 **(**Rice Stubble cut at height 35 cm) but was statistically at par with R_1 (Rice Stubble cut at height 5 cm) *i.e.*220.96 kg/ha-cm (Fig 1). The interaction effect between two treatments *i.e.* irrigation scheduling and rice stubbles was found to be non- significant at $p<0.05$. This might be due to reduction in evaporation and increase in WUE and also yield under R_2 was superior over R_3. The findings were consistent with those of Jack *et al.* (2010) [7] and Ashworth and McHugh (2010) [2].

3.4 Effect of irrigation scheduling on water productivity

Water productivity under different treatments was computed using net return obtained and water used in different stages of wheat growth and under the crops sown on rice stubbles. Table 2 displays data on water productivity as affected by irrigation schedules and rice stubbles. Amongst the irrigation schedules, irrigation at CRI (I_1) recorded significantly higher water productivity (0.52 ₹/m^3) than rest of the irrigations schedules. The lowest water productivity (0.29₹/m^3) was noted with four irrigations at CRI + maximum tillering + flowering + dough stage (I_5) treatment as shown in Fig 2. With increasing the irrigation levels from I_1 to I_5, water productivity decreased because more water was used in I_5 (four irrigations were given) as compared to I_1 (irrigation at CRI stage although the net return was more in I_5 as shown in table 2. Alsayim *et al.* (2013) [1] reported decrease in water productivity with increase in irrigation level.

3.5 Effect of rice stubbles on water productivity

Citation of data in table 2 regarding water productivity revealed that rice stubbles cut at different height treatments showed variation and exerted significant effect on water productivity (0.44 ₹/m^3) was maximum at R_2 (Rice Stubble cut at height 20 cm**)** which was significantly ($p<0.05$) superior to R_3 **(**Rice Stubble cut at height 35 cm) but was statistically at par with R_1 (Rice Stubble cut at height 5 cm), which had a water productivity of 0.39 ₹/m³ (Fig 2). The interaction effect between two treatments i.e. irrigation scheduling and rice stubbles was found to be non- significant at $p<0.05$. This result aligns with the findings of Kumar *et al.* (2016) [8]. Noellemeyer *et al.* (2013) [13] and Memon *et al.* (2013) [12], who observed higher water productivity under zero tillage compared to conventional tillage.

Table 2: Effect of various treatments on water productivity and WUE

Treatments	Water Productivity (₹/m^3)	WUE (kg/ha-cm)
Irrigation Scheduling(I)		
I_1- Irrigation at CRI Stage	0.52	324.26
I_2 –Irrigation at CRI + Boot Stage	0.38	217.39
I_3 –Irrigation at CRI + Milk Stage	0.41	226.54
I_4–Irrigation at CRI + Late Jointing + Milk Stage	0.36	187.10
I_5–Irrigation at CRI + Maximum Tillering + Flowering + Dough Stage	0.29	148.48
SEm(±)	0.022	6.74
LSD(p= 0.05)	0.075	23.33
Rice stubbles(R)		
R_1- Rice stubble cut at 5 cm height	0.39	220.96
R_2- Rice stubble cut at 20 cm height	0.44	234.78
R_3- Rice stubble cut at 35 cm height	0.34	206.51
SEm(±)	0.026	8.23
LSD (p= 0.05)	0.079	24.68
Interaction (I X R)	NS	NS

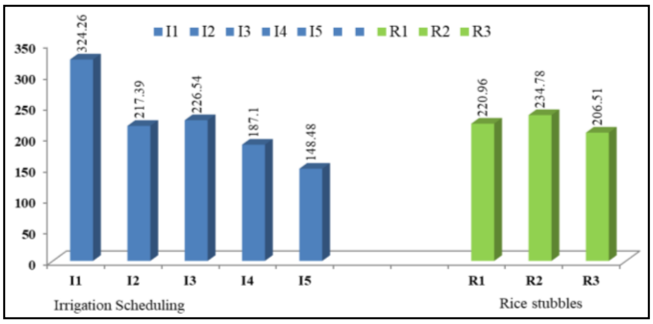

Fig 1: Effect of different treatments on WUE

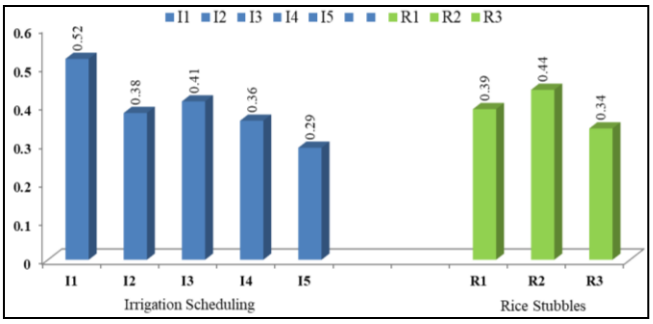

Fig 2: Effect of different treatments on water productivity

4. Conclusion

Considering the limitation of this investigation being conducted at a single site, the following broad conclusions can be drawn from one season. Water use efficiency and productivity were found to be highest in the case of I_1 (irrigation at the CRI stage), which was highly significant under the irrigation scheduling treatment tested. The replication R_2 (Rice stubble cut at 20 cm height) in the sub-plot showed best result among all the three replication for both water use efficiency and water productivity.

5. Reference

1. Alsayim HE, Rahman A, Nayel MH. Water-use efficiency of two wheat cultivars (*Triticum aestivum* L.) under tropical high terrace soil conditions. Asian Journal of Agriculture & Food Science. 2013;1:210-216.
2. Ashworth B, McHugh J. Crop residue management. University of Southern Queensland. 2010.
3. Bandyopadhyay PK, Mallick S. Actual evapo-transpiration and crop coefficient of wheat (*Triticum aestivum*) under varying moisture levels of humid tropical canal command area. Agricultural Water Management. 2003;59(1):33-47.
4. Barnard G, Kristoferson L. Agricultural residues as fuel in the third world, Earthscan – The Beijer Institute, Energy Information Programme, Earthscan. Borah N, Baruah R, Nath D, Hazarika K, Phukon A, Goswami K, and Baruah DB. 2016. Low energy rice stubble management through *in-situ* decomposition. Procedia Environmental Science. 1985;35:771-780.
5. Department of Agriculture and Co-operation, Directorate of Economics and Statistics, Govt. of India.2019. Area production and yield of wheat during 2018-19 in producing major states along with coverage under irrigation.
6. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research. 2nd Edition, John Wiley and Sons, New York, 1984. 680 p.
7. Jack M, Ashworth M, Desbiolles JMA, Tola E. (Ed. WAN-TF Association). Disc seeding in zero-till farming systems: A review of technology and paddock issues. Western Australian No-Tillage Farmers' Association: Northam, Western Australia. 2010.
8. Kumar A, Nand V, Kumar R. Effect of different levels of irrigation under integrated nutrient management (INM) on wheat (*Triticum aestivum* L.) for central plain agro climatic zone of Utter Pradesh, India. Plant Archives. 2016;16(1): 395-398.
9. Kumar D, Kumar R. Effect of establishment methods and irrigation levels on performance of wheat (*Triticum aestivum* L.). M.Sc (Ag) Thesis Dr. RPCAU, Pusa, Bihar. 2012.
10. Kumar V, Prasad UK. Response of wheat to different rates of zinc and nitrogen under varying levels of soil moisture. Indian Journal of Agronomy**.** 1986;31(4):405-406.
11. Lal RB. Irrigation requirement of dwarf *durum* and *aestivum* wheat varieties. Indian Journal of Agronomy. 1984;32(2):207-213.
12. Memon SQ, Mirjat MS, Mughal AQ, Amjad N. Effect of conventional and nonconventional tillage practices on maize production. Pakistan Journal of Agriculture Agricultural Engineering and Veterinary Science. 2013;29:155-163.
13. Noellemeyer E, Fernandez R, Quiroga A. Crop and tillage effects on water productivity of dry land agriculture in Argentina. Agronom., 2013;3:1-11.
14. Saren BK, Dey S, Mandal D. Effect of irrigation and sulphur on yield attributes, productivity, consumptive use, and consumptive use efficiency of wheat (*Triticum. aestivum*). Indian Journal of Agricultural Science. 2004;74(5):257-261.