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Effect of Rice Stubble and Irrigation Scheduling on Growth and Yield of Wheat Crop

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ABSTRACT

A field experiment was conducted during the winter *Rabi* season of 2021 at Dr. Rajendra Prasad Central Agricultural University, Pusa, Bihar, in order to study the possibility of improving the growth and yield of wheat under the effect of rice stubble and irrigation scheduling. The experiment was laid out in split-plot design, having 5 main-plot treatment, *viz.,* I_1, one irrigation at crown-root-initiation(CRI) stage; I_2, two irrigation at the CRI +booting stage; I_3, two irrigation at the CRI + milk stage; I_4, three irrigation at the CRI + late jointing +milk stage; I_5, four irrigation at the CRI + maximum tillering + flowering + dough stage and 3 subplot treatment, viz., 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)with 3 replication. Resulted indicated that, the growth parameters and yield attributes viz., of plant height, number of tillers/mrl, no. of tillers/m^2, spike length, number of grains/ear, crop emergence (number of plants/m^2), dry matter accumulation (g/m^2) and crop growth rate (g/m^2/day) were found to be maximum with I_5 irrigation level, which was significantly superior to I_1, I_2, and I_3 but statistically at par with I_4. 4 irrigations (I_5) and rice stubbles cut at a height of 20 cm (R_2) resulted in the highest growth and yield-attributing characters. The grain yield and straw yield were increased up to 4 irrigations (I_5). Treatment R_2 gave the highest grain and straw yields which was at par with R_1 treatment. The highest grain and straw yields were recorded with I_5R_2 treatment combination.

Key Words: Growth, Irrigation Scheduling, Rice, Stubble, Treatment, Yield

INTRODUCTION

Wheat (*Triticum aestivum* L.) is not only a major food source, but it is also an important crop for national food security due to its significant contribution to food grain buffer stock. Irrigation is one of the most important and costly inputs that have a direct impact on wheat growth and yield, and irrigation at the right time and quantity can increase yield. A change in the optimal temperature during wheat's vegetative and reproductive growth has a negative impact on the rate and duration of growth, as well as the yield. Irrigation can be timed to create a favourable soil moisture regime. The degree, duration and timing of the imposed soil-moisture deficit under limited irrigation determine grain yield reduction. The procedure for determining irrigation scheduling refers when and amount of water should be applied per irrigation. Proper scheduling of irrigation is critical to maximise the water, energy, and other manufacturing 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 critical in determining irrigation timing during the crop-growing season in irrigation projects.

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Furthermore, the biological and biochemical benefits of composted stubble are not significantly greater than those of incorporated stubble. Stubble incorporation aids in the degradation of organic matter, the stimulation of nitrogen fixation, and the stimulation of phosphorus, all of which result in an increase in plant available nutrients in the soil. Furthermore, repeated cultivation under rice stubble improves soil structure, which benefits the wheat crop and internal drainage, which benefits the rice crop. Wheat yield is maximised when wheat seeds are sown directly in a field containing rice

Table 1. Effect of rice stubble and irrigation scheduling on plant height (cm) and number of tillers/ meter row length (mrl)

Treatment	Plant Height (in cm)				No. of tillers/meter row length (mrl)			
Irrigation Scheduling (I)	30 DAS	60 DAS	90DAS	HARVEST	30DAS	60 DAS	90 DAS	HARVEST
I_1 - Irrigation at CRI Stage	18.06	45.48	72.77	80.85	32.15	66.95	59.52	51.01
I_2 –Irrigation at CRI+boot Stage	18.45	48.72	77.95	86.60	32.55	73.81	64.63	55.39
I_3 –Irrigation at CRI+ milk Stage	18.59	50.77	81.23	90.24	33.00	76.49	71.95	61.67
I_4 –Irrigation at CRI + late jointing + milk Stage	18.75	56.77	90.83	100.91	33.84	86.97	84.13	72.11
I_5 –Irrigation at CRI + maximum tillering+ flowering+ dough Stage	19.00	57.00	91.20	101.32	34.34	88.58	85.98	76.43
SEm(±)	0.22	1.52	2.44	2.71	0.85	1.99	2.08	1.79
LSD(*p*= 0.05)	NS	5.27	8.43	9.36	NS	6.90	7.21	6.19
Rice stubbles(R)								
R_1- Rice stubble cut at 5 cm height	18.47	51.67	82.67	91.85	30.62	78.46	73.17	63.28
R_2- Rice stubble cut at 20 cm height	18.86	54.21	86.74	96.36	30.91	81.79	76.66	66.27
R_3- Rice stubble cut at 35 cm height	18.38	49.36	78.98	87.74	30.20	75.43	69.89	60.42
SEm(±)	0.23	0.93	2.22	2.47	0.78	1.82	1.93	1.66
LSD (*p*= 0.05)	NS	2.78	6.66	7.40	NS	5.45	5.79	4.99
Interaction (IX R)	NS	NS	NS	NS	NS	NS	NS	NS

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Table 2. Effect of rice stubble and irrigation scheduling on Dry matter accumulation (g/m²) and Crop growth rate (g/m²/day)

Treatment	Dry matter accumulation (g/m²)				Crop growth rate (g/m²/day)				
Irrigation Scheduling (I)	30 DAS	60 DAS	90DAS	HARVEST	0-30	30-60	60-90	90-120	120-Harvest
I-Irrigation at CRI Stage	22.19	182.49	364.94	656.89	0.74	5.34	6.08	8.52	1.22
I_2 –Irrigation at CRI+boot Stage	22.01	198.15	396.27	713.29	0.73	5.87	6.60	9.25	1.32
I_3 –Irrigation at CRI+ milk Stage	22.31	220.60	441.17	794.11	0.74	6.61	7.35	10.29	1.47
I_4 –Irrigation at CRI + late jointing + milk Stage	22.41	239.21	478.38	861.09	0.75	7.23	7.97	11.16	1.59
I_5 –Irrigation at CRI + maximum tillering+ flowering+ dough Stage	22.54	257.96	515.87	928.56	0.75	7.85	8.60	12.04	1.72
SEm(±)	0.75	6.39	12.77	23.01	0.02	0.21	0.21	0.30	0.04
LSD(p= 0.05)	NS	22.10	44.20	79.63	NS	0.71	0.74	1.03	0.15
Rice stubbles(R)									
R_1- Rice stubble cut at 5 cm height	22.25	219.36	438.68	789.63	0.74	6.57	7.31	10.24	1.46
R_2- Rice stubble cut at 20 cm height	22.42	230.02	460.00	828.00	0.75	6.92	7.67	10.73	1.53
R_3- Rice stubble cut at 35 cm height	22.21	209.67	419.30	754.74	0.74	6.24	6.99	9.78	1.40
SEm(±)	0.52	5.77	11.66	20.78	0.02	0.20	0.19	0.27	0.04
LSD (p= 0.05)	NS	17.30	34.95	62.29	NS	0.59	0.58	0.82	0.12
Interaction (IX R)	NS	NS	NS	NS	NS	NS	NS	NS	NS

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stubble and nitrogen is applied recently until wheat tillering. It is a novel idea that will benefit farmers by saving them time when sowing wheat, resulting in increased overall production. Cultivation on rice Stubble will allow farmers to plan water rotation between fields to minimize crop water stress, as well as maximising the yield, in addition to increasing net returns through increased crop yields and crop quality. Rice stubbles on the plot will be cut at various heights, allowing crop residues left on the field to replenish soil moisture. We will be able to observe irrigation treatments at various stages of wheat growth.

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, Bihar. It is located on the Burhi Gandak river's southern bank, at 250 5900^0 N latitude and 840 400^0 E longitude, at an elevation of 52.3 m above mean sea level (mean sea level). The research field had a consistent topography and textural make-up and was linked to the main irrigation channel, which was linked to the farm tube well for consistent and timely irrigation. During the research period, drainage system arrangements were available to remove excess water. The trial was carried out in

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a calcareous sandy loam type of soil texture which comes under the soil order entisol. The soil testing results showed alkaline type of reaction with lower values of organic carbon, N, P and K. It was found that pH was 8.28, low organic carbon (0.42 %), low available nitrogen (201.2 kg/ha), high available phosphorus (P_2O_5) (17.18 kg/ha) and medium available potassium (K_2O) (120.05 kg/ha). The experiment was carried out in split-plot design (SPD) with three replications. It consisted of 5 main plots and 3 subplot *viz*., I_1(one irrigation at CRI stage), I_2 (two irrigation at the CRI +booting stage), I_3 (two irrigation at the CRI + milk stage), I_4 (three irrigation at the CRI + late jointing + milk stage), I_5 (four irrigation at the CRI + maximum tillering + flowering + dough stage) and sub-plot consists of 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). The variety used for wheat was HD2733. The RDF (Recommended Fertilizer Dose) of wheat was 120:60:40 kg/ha (NPK) respectively. The spacing was maintained at 20 cm (R x R). Line sowing and by manual broadcasting was done as per the treatment and mixed it with a rotavator. Wheat cv. HD 2733 was sown on 2nd December in all the plots during 2021 all the treatments. A standardized nitrogen dose has been used in two parts: ½ only at planting time as basal and the other half two day's later as top dressing. Whole amount of P_2O_5 and K_2O was applied as basal at the time of sowing. Pre-sown 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 the recommendations of the crops. Rice stubbles were cut at different height i.e. 5, 20 and 35 cm from 25.11.2021 to 30.11.2021. During the trial meteorological data were suitable for normal growth of the crop. The harvesting of the wheat crop began on in the last week of April, 2022, when the crop reached maturity. Observations on the growth parameter and wheat yield were assessed on the basis of the produced recorded from the net plot (4 m × 3.4 m).The statistical analysis was carried out as described by Gomez and Gomez (1984).

Growth parameter

Crop emergence, plant height, the number of tillers per metre row length (mrl), dry matter accumulation, and crop growth rate (CGR) were all measured in each plot at 30, 60, 90, and 120 days after sowing (DAS), as well as at harvest.

$$CGR = \frac{W_2 - W_1}{(T_2 - T_1)\ P}$$

Crop Growth Rate (CGR): The amount of dry matter produced per area of land per unit time, as well as the crop growth rate (CGR), were calculated using the formula & expressed in g/m^2 /day.

Where,

W_1: weight of dry matter at time t_1

W_2: weight of dry matter at time t_2

P: Land area

Yield and Yield Parameters

Yield attributing parameters were recorded at physiological maturity. All these observations include effective tillers/m^2, length of spike (cm), No. of grains/ear, test weight (1000 grains in gm), biological yield (grain + straw) and harvest index (%).

$$\textbf{H.I.} = \frac{\text{Economic yield (e.g. grain)}}{\text{Biological yield (e.g. grain + straw)}} \times 100$$

$$= \frac{\text{Sink}}{\text{Source}} \times 100$$

RESULTS AND DISCUSSION

Growth Parameters

Wheat plants grown with irrigation level at I_5 (irrigation at CRI +Maximum Tillering + Flowering + Dough Stage) showed maximum plant height as shown in (Table 1). 101.32 cm at harvest which was significantly superior to irrigation level at I_1 i.e. irrigation at CRI stage, I_2 i.e. irrigation at CRI + Boot stage and I_3 *i.e.,* irrigation at CRI+ Milk

Table 3. Effect of rice stubble and irrigation scheduling on yield and yield attributes and harvest index(%)

TREATMENT	No. of effective tiilers/m^2	Spike or ear length(cm)	No. of grains/ear	Test Weight (g)	Grain Yield(t/ha)	Straw Yield(t/ha)	Harvest Index (%)
Irrigation scheduling (I)							
I_1 - Irrigation at CRI Stage	284.76	8.10	30.27	38.53	2.90	4.73	37.96
I_2 –Irrigation at CRI+boot Stage	319.03	8.67	33.91	39.07	3.25	5.29	38.14
I_3 –Irrigation at CRI+ milk Stage	332.45	9.04	35.34	39.55	3.38	5.48	38.20
I_4 –Irrigation at CRI + late jointing + milk Stage	384.84	10.10	40.91	40.32	3.92	6.27	38.47
I_5 –Irrigation at CRI + maximum tillering+ flowering+ dough Stage	392.92	10.15	41.77	40.48	4.00	6.32	38.77
SEm(±)	9.97	0.27	1.06	1.04	0.10	0.16	0.26
LSD(p= 0.05)	34.49	0.94	3.67	NS	0.35	0.57	NS
Rice stubbles(R)							
R_1- Rice stubble cut at 5 cm height	342.30	9.20	36.39	39.12	3.48	5.63	38.35
R_2- Rice stubble cut at 20 cm height	358.93	9.65	38.15	39.32	3.65	5.90	38.42
R_3- Rice stubble cut at 35 cm height	327.17	8.79	34.78	38.92	3.33	5.37	38.10
SEm(±)	9.11	0.25	0.97	0.80	0.09	0.15	0.25
LSD (p= 0.05)	27.27	0.74	2.90	NS	0.28	0.45	NS
Interaction (IX R)	NS	NS	NS	NS	NS	NS	NS

stage but statistically at par with I_4(100.91cm) i.e. irrigation at CRI +Late Jointing + Milk stage.This is probably due to increasing the number of irrigation at different growth stages, which maintained various metabolic processes due to the presence of adequate moisture in the soil. Saren *et al* (2004), Brahma *et al* (2007) and Kumar *et al* (2016a.) all reported significant reductions in plant height as a result of decreased irrigation levelsAt harvest, plant height was maximum at R_2, rice stubble cut at height 20 cm (96.36 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 (91.85 cm) as demonstrated in (Table

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1). It could be because the rice stubbles at R_2 could hold enough moisture, resulting in improved soil health and higher uptake of available nutrients from the soil.Familiar results has been reported by Davari *et al* (2012), Verma and Pandey (2013), Meena and Singh (2013) and Kumar *et al* (2016b.) where they revealed that highest plant height and maximum tillers per meter square under zero tillage sown with rice residue retention followed by zero tillage with residue burning in both years.

Plants irrigated at I_5 *i.e.,* irrigation at CRI +maximum tillering + flowering + dough stage produce a greater number of tillers/mrl at 60 DAS as shown in table 1. (88.58 tillers/mrl) which was significantly superior to I_1 *.i.e.* irrigation at CRI stage, I_2 .i.e. irrigation at CRI + Boot stage and I_3 .i.e. irrigation at CRI + milk stage but was statistically at par with I_4 (86.97 tillers/mrl) i.e. irrigation at CRI + late jointing stage + milk stage,which might be due to more availability of water on I5 irrigation application. In the sub-plot treatment, plants grown with rice stubbles cut at 20 cm height i.e. R2 produce more no. of tillers/mrl (81.79 tillers/mrl) at 60 DAScompared to other treatments and was significantly superior over R_3 .i.e. rice stubbles cut at height 35 cm but was statistically at par with R_1 *i.e.,* rice stubbles cut at height 5 cm (78.46 tillers/mrl) as demonstrated in (Table 1).It might be due to increased crop residue load on the soil surface or incorporation into the soil created an impervious layer enough to hinder crop germination and subsequently its initial growth. These findings were in agreement with Kumar *et al* (2005) where increasing the rice crop residue @ 6-7 t/ha reduces the emergence of wheat as compared to residue removal and burning of residues. Also due to mortality of lately formed non-effective tillers. Similar studies were made by Singh *et al* (2006b)

Maximum dry matter accumulation was recorded at harvest at I_5 (928.56 g/m^2) i.e. irrigation at CRI +maximum tillering + flowering + dough stage which was significantly superior than I_1 i.e. irrigation at CRI stage, I_2 i.e. irrigation at CRI + boot stage and I_3 i.e. irrigation at CRI + milk stage but was at par with I_4 *i.e.,* irrigation at CRI+ late jointing+ milk stage (861.09 g/m^2)as presented in (Table 2). Plant photosynthetic activity is heavily reliant on dry matter accumulation in leaves and leaf area. More dry matter accumulation in leaves allowed the photosynthetic area to remain active for a longer period of time, which is responsible for overall plant growth Plants grown with rice stubbles cut at height 20 cm i.e. R_2 produced more dry matter (828 g/m^2) as compared to other treatments at harvest which was superior than R_3 i.e. rice stubbles cut at height 35 cm but R_2 was statistically at par with R_1 (789.63 g/m^2) i.e. stubbles cut at height 5 cmas presented in (Table 2). Also, in R_2 (rice stubbles cut at a height of 20 cm), crop height was maximised, implying that the taller the plant, the greater the dry matter production. Thapa *et al* (2019) found that zero-tillage plots with residue retention had higher dry matter.

Highestcrop growth rate (g/m^2/day) was found at 90-120 DASat I_5, irrigation at CRI + maximum tillering +flowering + dough stage (12.04 g/m^2/day) which was significantly superior than irrigation at I_1i.e. irrigation at CRI stage, I_2 i.e. irrigation at CRI + boot stage and I_3 i.e. irrigation at CRI + milk stage but was statistically at par with I_4, i.e. irrigation at CRI+ late jointing+ milk stage (11.16 g/m^2/day) as presented in (Table 2).The reason for this was that as the number of irrigations increased, so did the positive effect of water on cell division, cell enlargement, elongation, photosynthetic accumulation, and proper translocation. These findings in terms of growth parameters in the present investigation also finds support from the works of Yadav and Verma (1989), Bhan *et al* (1990) and Deshmukh *et al* (1992). In case of sub-plot treatment, maximum crop growth rate was recorded at 90-120 DAS at R_2, rice stubbles cut at height 20 cm (10.73 g/m^2/day) which was significantly superior than R_3 i.e. rice stubbles cut at height 35 cm but was statistically at par with R_1 i.e. rice stubbles cut at height 5 cm (10.24 g/m^2/day)

shown in the (Table 2). This might be due to residue retention in case of rice stubbles and R_2 shows more nutrient uptake due to better moisture availability which might have showed increased organic carbon and increased microbial population and infiltration rate, resulting in more favourable conditions for crop growth and development. This result is similar with the findings of Jat *et al* (2013); Ronanki and Behera (2018). But in case of R_3 (rice stubbles cut at height 35 cm), due to excess moisture holding in the root zone, temperature decreases which creates an anaerobic condition and slows down the uptake of nutrients due to slow metabolic processes.

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Yield and Yield Attributes

The maximum number of effective tillers m^2 (392.92 tillers/m^2), length of spike (10.15 cm), and number of grains/ear (41.77 grains/ear) were obtained at I_5 (irrigation at CRI +maximum tillering + flowering + dough Stage), which was comparable to I_4 (irrigation at CRI+ Late Jointing+ Milk Stage), and showed significant superiority over I_1 (irrigation at CRI), I_2 (irrigation at CRI + boot stage), and I_3 (irrigation at CRI + milk stage) as described in the (Table 3). The test weight, on the other hand, was not significantly affected by irrigation scheduling treatment. Thus, under maximum irrigation level obtained with I_5 (irrigation at CRI +maximum tillering + flowering + dough Stage), this was favourable environment for vegetative growth and development resulted in a greater number of yield attribute characters. This finding was similar to those of Shivani *et al* (2001), Saren *et al* (2004) and Brahma *et al* (2007).Except for the test weight, which is not significant in the case of rice stubbles, all other yield attributes such as number of effective tillers m^2 (358.93 tillers/m^2) length of spike (9.65 cm), and numbers of grains/ear (38.15) were significantly influenced by rice stubbles as demonstrated in the (Table 3).

Under R_2 (rice stubbles cut at height 20 cm) all the yield attributing characters were maximum. The might be due to proper translocation of nutrients and availability of moisture. This results correlates with Tripathi *et al* (2015) reported that the number of grains per spike were found in zero-tillage wheat with full residue retention, followed by zero-tillage wheat without residue, and were lowest in conventional tillage wheat with full residue incorporation.

I_5 (irrigation at CRI + maximum tillering + flowering + dough Stage) produced the highest grain yield (4 t/ha) and straw yield (6.32 t/ha) as shown in the (Table 3). This could be attributed to adequate moisture availability, which contributed to improved growth parameters and yield characteristics. Irrigation at CRI (I_1) produced the lowest grainyield (2.90 t/ha)due to a lack of moisture during the growth period, which reduced yield attributes and resulted in low grain and straw yield. Kumar *et al* (2016a) and Ahmad *et al* (2016) all reported similar findings. R_2 grain (3.65 t/ha) and straw yield (5.90 t/ha) was significantly higher than R_3 in sub-plot treatment and was at par with R_1 as shown in the table 3, because the number of tillers was higher in R_2 treatment. Yadav *et al* (2005) reported similar findings.

CONCLUSION

Irrigation at CRI +maximum tillering + flowering + dough Stage (I_5) was found to be optimal for the wheat crop when all growth parameters, yield attributes, and yield were considered. In case of rice stubbles, rice stubbles cut at height 20 cm (R_2) above the ground level produced maximum grain and straw yield which was superior over R_1 (Rice Stubble cut at height 5 cm) and R_3 (Rice Stubble cut at height 35 cm).

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