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Effect of Irrigation Scheduling and Fertility Management on Growth and Yield Parameters of Basmati Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The data revealed that the potential effect of irrigation scheduling and fertilizer management on plant height, number of tillers, dry matter accumulation (g plant^{-1}), leaf area index, panicle length, number of panicle, number of grains per panicle and 1000- grains weight, and yields of Basmati rice. The maximum plant height and numbers of tillers were recorded in IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage and 150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT at all the stages of crop growth, while the minimum plant height and numbers of tillers were observed with the application of IW/CPE 0.8 throughout the growth stage and 100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT at all the growth stages. Similarly, the maximum dry matter accumulation (g plant^{-1}) and leaf area index were recorded in IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage and 150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT and significantly superior over rest of the treatments, while the minimum dry matter accumulation (g plant^{-1}) and leaf area index were weighted with IW/CPE 0.8 throughout the growth stage and 100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT. Yield attributing characters like panicle length, number of pancle, number of grains per panicle and 1000- grains weight exhibited

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variations due to different irrigation and fertilizer management. With the application of IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage and 150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT highest mean panicle length, number of pancle, number of grains per panicle and 1000- grains weight was recorded. The highest grain yield, straw yield and biological yield was recorded in IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage and 150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT and the lowest grain yield, straw yield and biological yield was recorded in IW/CPE 0.8 throughout the growth stage and 100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT.

Keywords: O. sativa; growth and yield parameters; irrigation scheduling; fertilizer management.

1. INTRODUCTION

“Rice (*Oryza sativa* L.) is important staple food crop consumed by majority (more than 60%) of world’s population, providing approximately 20% of total energy intake for humans. It is a high caloric food, which contain 75% starch, 6-7% protein, 2-2.5% fat, 0.8% cellulose and 5-9% ash. So, it is used as staple food crop and eaten as cooked rice and also used for various preparation and has commercial and industrial importance. Beside grains, its straw and rice hulls are used as fodder, mulching, packing and as insulation materials *etc.* It plays a vital role in national food security for millions of rural households. Rice is the substantial part of protein intake for millions of people living in poverty in Asia. Asia's food security depends mainly on irrigated low land rice fields, which produces three-quarters of all rice harvested. In Worldwide, rice is cultivated over an area of about 164.19 million hectares with production and productivity 513.02 million metric tons and 31.24qha^{-1}, respectively” (Anonymous, 2021). “India occupies a pride place in rice production among the food crops cultivation in the world. Area of rice in India increased 1.5 times, productivity 3 times (2752 kg ha^{-1}) and production > 4 times (124.37 million tonnes). West Bengal is the highest producing state and other leading states are Uttar Pradesh, Punjab and Chhattisgarh. In Uttar Pradesh, rice is grown on 5.95 million hectares area with production of 15.52 million tonnes and productivity of 26.34 qha^{-1}” (Anonymous, 2021). “Irrigation scheduling is the decision of when and how much water to apply to a field. Its purpose is to maximize irrigation efficiencies by applyingthe exact amount of water needed to replenish the soil moisture to the desired level. Irrigation scheduling saves water and energy. The scarcity of water for agriculture production is becoming a major problem in many countries, particularly in world’s leading rice-producing countries like China and India. Rice cultivation in India is predominantly practiced under transplanting method that involves raising, uprooting and transplanting of seedlings. This technique requires continuous ponding of water” [1,2]. “The fertilizer N recovery efficiency has been found to be around 30-40% in rice with the current practices. Nitrogen nutrition due to the considerable impact on growth parameters and physiological traits of rice is important. The percentage of light penetration, photosynthesis active radiation, light use efficiency, dry matter partitioning to different parts are affected by the amount of nitrogen. Nitrogen is typically the nutrient that most often limits rice yields and hence the nutrient needed in largest quantity among the fertilizer. Appropriate doses of N fertilizer and establishment method is important to increase nitrogen use efficiency in rice” (Ranjan and Yadav, 2019). “Nitrogenous fertilizers are one of the most important fertilizers that influence rice yields. It promotes tillers development, yield attributes and increases yield. The rice crop produced maximum grain yield in response to nitrogen application in three splits. Scheduling of irrigation in rice plays a major role in obtaining higher yields as well as higher water productivity” (Keerthi, et al., 2018). Water management is one of the major factors responsible for achieving better harvest in crop production. Efficient irrigation through timely supply of water in desirable amount and with proper irrigation method not only improves the crop yields but also improve water use efficiency. Phogat et al. (2009) reported that “ the growth yield attributes and yield of rice increased significantly with the increase in number of irrigation. Applications of three irrigations significantly increased grain yield by 15.5% & 52.8% over two and one irrigations, respectively. Adequate supply of moisture in soil helps in proper utilization of plant nutrients, resulting in proper growth and high yield. Irrigation and fertilizer management are important agronomic practices for higher yield. Irrigation influence favor the growth and yield attributes of rice by supplementing the water need of the crop. It also enhances availability of different nutrients to crop plants". In a field investigation carried out by [3] with rice crop, they reported that "irrigation applied at flowering and grain filling stages significantly increased grain yield of rice over that of pre-flowering and grain filling stages". Bharti and Prasad (2002) found that "grain yield of rice increased significantly up to an IW/CPE ratio of 0.8 with irrigations, such of 5cm depth. Irrigation thus, plays a vital role in increasing the growth and yield of rice. So in researches, water use efficiency measured is very important". Tomer et al*.* (1992) showed that "consumptive use of water was increased significantly up to two irrigations applied at pre-flowering and fruiting stages but water use efficiency was increased only up to one irrigation applied at flowering stage in rice". Yadav et al*.* (1999) reported that "consumptive use of water increased by increasing levels, whereas water use efficiency decreased with irrigation".

2. MATERIALS AND METHODS

A field experiment was conducted at Crop Research Center (CRC) of Sardar Vallabhbhai Patel university of Agriculture & Technology, Meerut, Uttar Pradesh during the *kharif* season (2022) .The details of the experimental materials used and the methods adopted during the course of investigation are described briefly in this chapter.

2.1 Experimental Site and Location

The experiment was conducted at Crop Research Centre (CRC), Chirodi of Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut situated in Indo-Gengetic Plains of Western Uttar Pradesh in Western Plain Zone. The CRC is geographically located at 29° 08' 12'' N latitude, 77° 40' 52'' E longitudes and at an elevation 232 meters above the sea level.

2.2 Soil Moisture Constants of the Experimental Soil

The soil moisture retention capacities at saturation, field capacity and permanent wilting point and bulk density of the soil prior to conducting the experiment were estimated from 0-15 and 15-30 cm soil depths by following procedures of Dastane et al. (1967) and the estimated data are presented in Table 1.

2.3 Weather and Climate

The data on climatic parameters such as rainfall (mm), mean maximum and minimum temperature, evaporation, air velocity and relative humidity recorded at meteorological observatory, Sardar Vallabhbhai Patel University of Agriculture & Technology Meerut, (U.P.) for the year 2022 was used in the present study. The climate of this region is characterized as semi-arid and sub-tropical. The summer is very hot and dry while winters are too cold. Moderate rainfall and wide temperature variation is the characteristic features of the semi-arid and sub-tropical climate. Generally, South- West monsoon sets in the third or fourth week of June, reaches its peaks in July and August, and continues up to September, cyclonic weather leads to few winter rains. The area receives mean annual rainfall of 845 mm, of which 80-90 per cent is received from June to September. Winter season extends from November to February, whereas frost occurs generally in the end of December and may continue up to the end of January. The mean minimum temperature reaches as low as 3°C in winters, while during summer the mean maximum temperature varies from 43-45°C in the month of May. The meteorological data showed that average maximum and minimum weekly temperature varied from 40.3 and 38.5^{0}C to 15.9 and 16.1^{0}C during the crop period in the year 2022, respectively. However, the mean maximum and minimum relative humidity varied from 95.8 and 88.1 to 46.8 and 41.7% during the crop period in the year 2022, respectively. Though, the total rainfall 587.6 mm was received during year of investigation, respectively.

2.4 Varietal Description

Pusa Basmati 1637 is a semi-dwarf Basmati rice variety with sturdy stem and plant height ranging from 95 - 100 cm. Therefore, it does not lodge. It takes 115-120 days for seed to seed maturity, the shortest duration for any Basmati rice variety released so far. This variety has given yield in the range of 4.2 to 6.5 tons/ha in large scale demonstrations conducted in the Basmati growing regions of Punjab, Haryana, Delhi and Uttar Pradesh. The variety was developed by the Division of Genetics, Indian Agricultural Research Institute, New Delhi.

2.5 Design and Layout of the Experiment

The experiment was laid out in a split plot design with two irrigation scheduling as first factor treatments and second factor treatments has six fertilizer management of rice are replicated thrice. The experimental field was provided with main irrigation channels and sub- Irrigation channels as shown in layout plan and the individual plots were demarcated by bunds. The layout plan of the experiment is depicted Table 2.

2.6 Cultural Operations

2.6.1 Nursery raising

The seedling of rice variety PB-1637 was raised in nursery by 'Wet bed method'. Seed beds of 10 x 1.5 m size was prepared in dry condition. On sowing date, the beds was flooded with water and puddled. After levelling, sprouted seed was sown then beds kept saturated initially up to a week and then submerged with a thin layer of water throughout. These beds were irrigated on alternate days during rainless period.

2.6.2 Application of fertilizers

"The amount of N, P and K was applied through urea, SSP and muriate of potash, respectively. Half of N and full dose of P and K was applied as basal before lost plough of field. The remaining 50% N was top dressed in splits at active tillering

Table 1. Moisture retention characteristics of the experimental soil

Soil depth (cm)	Moisture per cent at			Bulk density (g cm^{-3})	Available soil moisture (mm)
	Saturation (0 bar)	Field capacity (0.2 bar)	Permanent wilting point (15 bar)		
0-15	26.2	24.6	14.1	1.32	20.79
15-30	25.8	23.0	13.6	1.35	18.83

Table 2. The experiment was conducted as per the plan given below

S. No.	Particulars	
1	Design	Split Plot Design
2	No. of treatments combination	Main plot : 5 Sub-plot : 6
3	No. of replications	3
4	Total plots	90
5	Gross plot size	10 m x 3.0 m = 30 m^2
6	Net plot size	8 m x 2.5 m = 20 m^2
7	Variety	Pusa Basmati- 1637
8	Spacing	25 x 10 cm 20 x 10 cm
9	Irrigation channel	Main irrigation – 2m Sub –irrigation -1m
10	Season	*Kharif* 2022

Table 3. Treatment details

Treatments		Symbols Used
Irrigation Scheduling (First factor):		
T_1	IW/CPE 0.8 throughout the growth stage	I_1
T_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	I_2
T_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	I_3
T_4	IW/CPE 1.0 throughout growth stage	I_4
T_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	I_5
Fertilizer Management (Second- factor):		
T_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	N_1
T_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	N_2
T_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	N_3
T_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	N_4
T_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	N_5
T_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	N_6

stage and at panicle initiation stage of rice. The amount of PSB @ 5 kg ha^{-1}, Azotobacter was applied @ 20 kg ha^{-1} and FYM was 0.5% N, 0.2% P and 0.5% K was applied in the soil at one week after transplanting of rice. The application of N, P and K of the basis STCR equation (developed by IARI) is followed 6.97 X T - 0.38 X SN, 5.73 X T - 4.81 X SP, 3.92 X T - 0.28 X SK" (Argal. 2017).

2.7 Growth and Development Studies

2.7.1 Plant height

The main shoot of five plants was tagged at random in each plot and height of the shoot was measured in centimeter at 30, 60, 90 DAT and at harvest. The height of each plant was measured from the base of the plant to the tip of the highest fully developed leaf before heading and up to tip of the panicle after heading.

2.7.2 Number of tillers (No. m^{-2})

In each net plot, five plants was selected at random in four stages *viz.*, 30, 60, 90 DAT and at harvest and the total tillers was counted and expressed as total number of tillers $hill^{-1}$.

2.7.3 Leaf area index

Leaves are the primary photosynthetic organs of the plant. Leaf area index, area of leaf per unit area of soil surface was measured with the help of PAR/LAI ceptometer (Accu PAR model LP-80). The leaf area index was calculated based on the above canopy measurement along with other variables.

2.7.4 Dry matter accumulation (g m^{-2})

Dry matter accumulation was recorded by selecting five hills randomly from observation `row of each plot. Selected hills was cut carefully closed to the ground surface at 30, 60, 90 DAT and at harvest stage. After sun drying these samples was collected in paper bags by cutting in small pieces and was put in a electric oven at 60$\pm$1 ^{0}C till constant weight. After this the weight was recorded on electronic balance and expressed as dry matter accumulation in g m^{-2}.

2.7.5 Crop growth rate (g m-2/ day)

The daily increment in crop biomass is termed as crop growth rate and it was computed at 0-45, 45-70 and 70-90 DAS and 90-at harvest by using the formula as suggested by Watson (1952) and it is expressed in g/m2/day.

$$CGR = (W_2 - W_1) \; / \; P(T_2 - T_1)$$

Where, P = Ground area, W_1 = Dry weight of plant/m^2 recorded at time T_1, W_2 = Dry weight of plant/m2 recorded at time T_2, T_1 and T_2 were the interval of time, respectively in days.

2.7.6 Relative growth rate (g g-1 day^{-1})

It is the rate of increase in crop biomass per unit of biomass present and is expressed as g/g/day. It was also determined on the growth, when dry matter production was noted. It was worked out by the formula as suggested by Watson (1952), and determined at 0-45, 45-70 and 70-90 DAS and 90-at harvest.

$$RGR = (\ln W_2 - \ln W_1) / (t_2 - t_1)$$

Where, W1 and W2 are the dry weights (g) at times t1 and t2 in days, respectively. In is natural logarithm. RGR is expressed in g g^{-1} day^{-1}.

2.8 Yield and Yield Attributes

2.8.1 Number of effective tillers

Shoots bearing panicles at the time of harvesting was recorded from ten marked plants from each plot as per procedure followed for counting number of tillers at each successive stage, considered as number of effective tillers.

2.8.2 Panicle length (cm)

Twenty panicles were selected at the time of harvesting from five marked plants from each plot and recorded the panicle length in cm on average basis.

2.8.3 Number of filled and unfilled grains per panicles

Ten panicles was selected randomly from each plot at the time of harvesting and number of filled and unfilled grains per ten panicles was counted and average number of grains per panicles was worked out.

2.8.4 Test weight (g)

Samples of one thousand filled grains from the produce of the net plots were counted and their weights were recorded in grams and mean was taken to represent it as 1000-grain weight.

2.8.5 Grains yield (q ha-1)

The harvested plants from net plot area was threshed manually and each plot yield was separately sun dried, cleaned by winnowing and weighed. Grain yield was computed at 14 per cent moisture content and expressed in q ha^{-1}.

2.8.6 Straw yield (q ha-1)

Straw yield was obtained by subtracting the grain yield from the total produce per plot. It was finally expressed in q ha^{-1}.

2.8.7 Biological yield (q ha-1)

The crop in each net plot was harvested bundled, labelled and dried in the field for 4-5 days. Bundles was weighed just before threshing to record biological yield per plot and expressed in q ha^{-1}.

2.8.8 Harvest index (%)

Harvest index is the ratio of economic yield (grain) to biological yield (grain + straw) and calculate as follows:

H.I (%) = Grain yield (q ha^{-1}) / Total biological yield (q ha^{-1}) x 100

2.9 Standard Error of Mean

Standard error of mean (SEm±) was calculated as follows:

Standard error of mean = √EMSS / r

Where,

SEm± = Standard error of mean EMSS = Error mean sum of squares
r= Number of replication on which the observation is based

2.10 Critical Difference

The data obtained was subjected to statistical analysis as outlined by Gomez and Gomez [4]. The treatment difference were tested by lest significance difference at 0.05% of probability and calculated by using the following formula:

$$CD = \sqrt{\frac{2 \times \text{Error mean square}}{r}} \times t_{0.05}$$

Where,

CD = Critical difference
r = Number of replications of the factor for which C.D. is to be calculated.
t0.05= Value of percentage point of ‘t’ distribution for error degree of freedom at 5 per cent level of significance.

3. RESULTS AND DISCUSSION

The effect of irrigation scheduling and fertility management on growth parameters *viz.,* plant height, number of tillers, number of panicle, panicle length (cm), number of grains/panicle, leaf area index, and yield parameters *viz.,* dry matter accumulation**,** test weight (1000 grains weight), grain yield (q ha^{-1}), straw yield (q ha^{-1}), biological yield, harvest index (%) of rice. Data were recorded on various observations of crop growth and yield attributes at different physiological stages of crop development are described here.

3.1 Effect of Irrigation Scheduling and Fertilizer Management on Plant Height (cm) at Different Stages of Basmati Rice

Data on plant height was recorded at 30, 60, 90 days after transplanting (DAT) and at harvest under different irrigation scheduling and fertility levels are presented in Table 1. The data revealed that plant height increased with advancement of crop growth till 90 DAT and thereafter got stabilized. An examination of the data revealed marked effect of irrigation levels and fertilizer management on plant height at all the stages of observation. Application of different levels of irrigation had significant effect on plant height at all the stages of observations. However, treatment I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage) recorded highest plant height as compared to other irrigation levels, which was at par with I3 (IW/CPE 0.8 up to panicle stage and thereafter 1.2 up to dough stage) and I4 (IW/CPE 1.0 throughout growth stage) at all the stages of crop growth. Similarly, it is indicated from the data in the table that plant height also differs with different fertilizer management. Amongst, all the treatments, application of N6 treatment (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) recorded superior plant height (45.2, 81.8, 98.3 and 99.4 cm), which was at par with N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) and N5 (150% RDN: 4 equal splits at 15, 30, 45 & 60 DAT) at all the stages of observations. However, the non-significant increment in plant height was observed from 150% RDN: 4 equal splits at 15, 30, 45 & 60 DAT to 125% RDN: 4 equal splits at 15, 30, 45 & 60 DAT at all the stages. The lowest plant height was recorded under N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT) at all the growth stages. Plant height (cm) was not significantly influenced by the interaction effect between different irrigation scheduling and fertilizer management of rice. Kumavat et al. (2019) observed that at 0kPa the highest plant height (99.5 cm) was recorded and at par with 10kPa irrigation thresholds (98.3 cm),at 10kPa throughout the growing season except 40kPa during tillering to flowering recorded the lowest values of plant height. Rahman et al*.* [5] concluded that plant height, panicle number, panicle length, weight of 100 grain, number of tillers, total dry matter and yield were decreased with water stress. Maheshwari et al. [6] evaluated growth parameters i.e. productive tillers, root volume, plant height, crop growth rate are more at IW/CPE 1.2 followed by 1.0 and lower yield, reduction in growth parameters were observed at IW/CPE 0.8. Singh et al*.* (2014) significantly taller plant height recorded with 0.7 IW/CPE ratio might be due to rapid cell division under adequate water supply. Shorter plant height recorded under 0.5 IW/ CPE ratio was mainly due to poor growth caused by stress.

3.2 Effect of Irrigation Scheduling and Fertilizer Management on Number of Tillers (m-2) at Different Stages of Basmati Rice

The treatment, I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage) recorded significantly highest number of tillers (127.6, 279.3, 266.7 and 252.4 m^{-2}), which was at par with I3 (IW/CPE 0.8 up to panicle stage and thereafter 1.2 up to dough stage) and I4 (IW/CPE 1.0 throughout growth stage) at all the stages of observations that are 60 DAT, 90 DAT and at harvest, respectively. The lowest number of tillers were observed in I1 (IW/CPE 0.8 throughout the growth stage) treatment. Data in the Table 5 indicated that number of tillers also significantly influenced by different fertilizer management treatment. Amongst all the treatments, the treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) recorded highest number of tillers (126.1, 272.2, 258.2 and 248.5 m^{-2}) at 30, 60, 90 and at harvest of observations, which was at par with N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) and that was significantly superior then remaining fertilizer management treatments. However, the significantly lowest number of tillers were recorded under N1 treatment (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Number of tillers (m^{-2}) was not significantly influenced by the interaction effect between different irrigation scheduling and fertilizer management of rice. Das et al*.* [7] recorded two irrigation schedules with 7 cm of water after 3 and 5 days of infiltration of applied water and revealed that out of 3 years, these treatments produced statistically similar number of effective tillers m^{-2} and 1000 gram weight for two years, whereas, in case of number of grains $panicle^{-1}$ these treatments remained statistically at par with each other during all the three years.

3.3 Effect of Irrigation Scheduling and Fertilizer Management on dry Matter Accumulation (g m2) at Different Stages of Basmati Rice

Data on dry matter accumulation recorded at 30, 60, 90 DAT and at harvest under different irrigation scheduling and fertilizer management treatments are presented in Table 6. It is clear from the data in the table that dry matter accumulation was significantly influenced by irrigation scheduling and fertilizer management. Amongst the irrigation scheduling, the treatment I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage) recorded significantly higher dry matter accumulation, which was at par with I3 (IW/CPE 0.8 up to panicle stage and thereafter 1.2 up to dough stage) at all the stages as compared to other treatments. The lowest dry matter accumulation recorded with I1 (IW/CPE 0.8 throughout the growth stage) treatment. Similarly, the data given in table showed that at dry matter accumulation significantly varied with fertilizer management treatment all the stages of observations. Amongst all the treatments, the N6 treatment (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) obtained significantly higher dry matter accumulation as compared to remaining treatments 373.1, 872.1, 991.2 and 1343.1, which was at par with N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) respectively, at 30, 60, 90 DAT and at harvest stages. The significantly lowest dry matter accumulation was found under treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT) at all the growth stages. Dry matter

Table 4. Effect of irrigation scheduling and fertilizer management on plant height (cm) at different stages of Basmati rice

Treatments		Plant height (cm)`			
		30 DAT	**60 DAT**	**90 DAT**	**At harvest**
(A) Irrigation Scheduling					
I_1	IW/CPE 0.8 throughout the growth stage	37.8	73.4	89.9	90.3
I_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	40.2	75.0	94.2	94.5
I_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	42.8	77.3	95.1	95.6
I_4	IW/CPE 1.0 throughout growth stage	41.7	76.3	94.0	94.4
I_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	43.5	78.6	96.3	97.2
SE(m)±		**0.72**	**0.95**	**1.03**	**1.12**
C.D. (P=0.05)		**2.16**	**2.84**	**3.06**	**3.40**
(B) Fertilizer Management					
N_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	35.4	70.3	87.5	88.1
N_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	36.2	72.6	88.6	90.0
N_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	38.3	75.2	93.8	94.3
N_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	44.6	79.1	96.2	97.6
N_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	42.2	77.3	95.1	96.4
N_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	45.2	81.8	98.3	99.4
SE(m)±		***1.21***	***1.28***	***1.90***	***1.94***
C.D. (P=0.05)		***3.61***	***3.82***	***5.68***	***5.80***

Table 5. Effect of irrigation scheduling and fertilizer management on number of tillers (m-2) at different stages of Basmati rice

Treatments		Number of tillers (m-2)			
		30 DAT	**60 DAT**	**90 DAT**	**At harvest**
(A) Irrigation Scheduling					
I_1	IW/CPE 0.8 throughout the growth stage	104.4	235.3	223.1	217.9
I_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	115.2	249.4	238.3	229.6
I_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	126.8	278.4	261.4	252.8
I_4	IW/CPE 1.0 throughout growth stage	124.2	276.9	259.8	250.6
I_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	127.6	279.3	266.7	252.4
SE(m)±		***1.14***	***0.86***	***1.91***	***1.84***
C.D. (P=0.05)		***3.40***	***2.56***	***5.70***	***5.51***
(B) Fertilizer Management					
N_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	112.2	250.2	237.2	227.6
N_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	113.7	251.4	238.1	228.4
N_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	115.8	257.5	244.7	231.1
N_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	122.2	270.3	252.4	242.6
N_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	117.7	262.2	248.6	235.4
N_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	126.1	272.2	258.2	248.5
SE(m)±		***2.12***	***1.06***	***2.54***	***2.41***
C.D. (P=0.05)		***6.32***	***3.16***	***7.60***	***7.22***

Table 6. Effect of irrigation scheduling and fertilizer management on dry matter accumulation (g m2) at different stages of Basmati rice

Treatments		Dry matter accumulation (g m2)			
		30 DAT	60 DAT	90 DAT	At harvest
(A) Irrigation Scheduling					
I_1	IW/CPE 0.8 throughout the growth stage	307.6	833.1	938.1	1279.8
I_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	356.1	848.9	969.2	1322.6
I_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	387.6	883.7	1005.1	1364.7
I_4	IW/CPE 1.0 throughout growth stage	386.5	853.5	978.1	1332.7
I_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	391.5	885.7	1012.3	1367.9
SE(m)±		***1.54***	***2.45***	***4.32***	***2.73***
C.D. (P=0.05)		***4.61***	***7.32***	***12.92***	***8.19***
(B) Fertilizer Management					
N_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	335.2	839.8	957.4	1304.6
N_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	358.6	843.5	968.5	1313.9
N_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	361.4	854.3	971.3	1324.3
N_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	370.2	866.9	983.4	1332.9
N_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	365.4	857.4	975.8	1325.4
N_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	373.1	872.1	991.2	1343.1
SE(m)±		***2.21***	***3.12***	***5.10***	***3.41***
C.D. (P=0.05)		***6.60***	***9.35***	***15.26***	***10.21***

accumulation (g m[2]) was not significantly influenced by the interaction effect between different irrigation scheduling and fertilizer management of rice. Khalifa et al. [8] studied the effect of 3 irrigation intervals (on every 4th, 7th and 10th day) and found that irrigation at every 4 day recorded the highest grain yield which was statistically at par with grain yield at every 7th day.

3.4 Effect of Irrigation Scheduling and Fertilizer Management on Leaf Area Index at Different Stages of Basmati Rice

The data on leaf area index recorded at 30, 60, 90 DAT under different irrigation scheduling and fertility levels treatments are presented in Table 7 The effect of irrigation scheduling, significantly highest LAI (2.52, 3.70 and 4.04) was recorded under treatment I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage) at all the stages *viz.* 30, 60 and 90 DAT respectively. However, the significantly lowest LAI was found under Treatment I1 (IW/CPE 0.8 throughout the growth stage). Similarly, the LAI was also significantly affected by different fertilize management. The significantly highest LAI 2.49, 3.76 and 4.09 was recorded at 30, 60 and 90 DAT respectively due to fertilize management under treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT). The significantly lowest LAI was recorded under treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Leaf area index was not significantly influenced by the interaction effect between different irrigation scheduling and fertilizer management of rice.

3.5 Effect of Irrigation Scheduling and Fertilizer Management on Yield Attributes Characters of Basmati Rice

3.5.1 Panicle length (cm)

The data recorded on panicle length (cm) as influenced by irrigation levels and fertilizer management are presented in Table 8 It is observed from the data in the table that irrigation scheduling significantly influenced the panicle length. Amongst the treatments, the treatment I5 (IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage) recorded maximum panicle length (27.5 cm) followed by I3 (IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage) as compared to the remaining treatments. The treatment I1 (IW/CPE 0.8 throughout the growth stage) recorded significantly lowest panicle length (22.3 cm). Similarly, the application of 150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT (N6) recorded significantly highest panicle

Table 7. Effect of irrigation scheduling and fertilizer management on leaf area index at different stages of Basmati rice

Treatments		Leaf Area Index		
		30 DAT	**60 DAT**	**90 DAT**
(A) Irrigation Scheduling				
I_1	IW/CPE 0.8 throughout the growth stage	2.15	3.40	3.76
I_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	2.23	3.52	3.82
I_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	2.49	3.66	4.35
I_4	IW/CPE 1.0 throughout growth stage	2.25	3.56	3.92
I_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	2.52	3.70	4.04
SE(m)±		***0.02***	***0.05***	***0.06***
C.D. (P=0.05)		***0.05***	***0.14***	***0.19***
(B) Fertilizer Management				
N_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	2.01	3.31	3.56
N_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	2.22	3.52	3.81
N_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	2.29	3.56	3.85
N_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	2.44	3.63	4.05
N_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	2.31	3.58	3.95
N_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	2.49	3.76	4.09
SE(m)±		***0.03***	***0.06***	***0.07***
C.D. (P=0.05)		***0.08***	***0.16***	***0.21***

length (27.7 cm) followed by N4 and N3. Significantly lowest panicle length (20.3 cm) was found under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Khalifa et al. [8] revealed that with the 3 irrigation intervals (irrigation every 4th, 7th and 10th day), irrigation at every 4th day recorded the highest yield attributes (number of panicles m^{-2}, panicle length, number of filled grains panicle 1000-grain weight) which were statistically at par with that obtained by irrigation at every 7th day.

3.5.2 Number of panicle

Data recorded on number of panicle as influenced by irrigation scheduling and fertilizer management are presented in Table 8 It is obvious from the data in the table that irrigation scheduling significantly influenced the number of panicle production. Amongst the treatments, the treatment I5 (IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage) recorded higher number of panicle (138.2) followed by I3 (IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage) as compared to the remaining treatments. The treatment I1 (IW/CPE 0.8 throughout the growth stage) recorded lowest (126.7) number of panicle. Similarly, the variation in number of panicle due to fertilizer management treatments was also observed. The treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) recorded significantly higher number of panicle (139.4) as followed by N4 and N3. The significantly lowest number of panicle was found under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT).

3.5.3 Number of grains/panicle

The data recorded on number of grains/panicle as influenced by irrigation scheduling and fertilizer management are given in Table 8. It is obvious from the data in the table that number of grains/panicle significantly varied due to irrigation scheduling. Amongst all the irrigation treatments, the significantly higher number of grains/panicle (152.8 $panicle^{-1}$) was recorded under I5 (IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage), which was at par with I3 (IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage). The significantly lowest number of grains/panicle (136.5 $panicle^{-1}$) was recorded under the treatment I1 (IW/CPE 0.8 throughout the growth stage). Variations number of grains/panicle due to fertilizer management treatments was significant. Amongst the fertilizer treatments, the treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) recorded superior number of grains/panicle (145.9 $panicle^{-1}$), which was at par with N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) and N3 (125% RDN: 4 equal splits at 15, 30, 45 & 60 DAT) as compared to the remaining treatments. However, the significantly lowest number of grains/panicle (138.7) was found under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Gill and Singh [9] evaluated the effect of two irrigation schedules i.e., irrigation after 2 and 3-days interval and found that at 2-days interval gave significantly more yield (36.9 q ha^{-1}) than 3-day intervals due to significantly higher values of effective tillers and number of grains per panicle**.**

3.5.4 1000- grains weight (g)

Data recorded on 1000- grains weight of rice under different treatments are presented in Table 8. It is clear from the data in the table that 1000-grains weight of rice varied significantly due to irrigation scheduling. Amongst all the treatments, the highest 1000- grains weight (23.8 g) was recorded under I5 (IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage) followed by I3 (IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage). The lowest 1000- grains weight recorded in I1 (IW/CPE 0.8 throughout the growth stage) treatment. Similarly, the variations in 1000-grains weight due to fertilizer management treatment were also observed. The significantly higher 1000- grains weight (23.8 g) was observed in treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) followed by N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT). The significantly lowest 1000- grains weight (20.8 g) was recorded under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Ramakrishna et al. [10] reported that yield attributing characters like panicle length, number of grains $panicle^{-1}$ and test weight varied non- significantly among two irrigation treatments i.e. irrigation after one day of drainage and three days after drainage of applied water.

3.6 Effect of Irrigation Scheduling and Fertility Management on Grains Yield, Straw Yield, Biological Yield (q ha-1) and Harvest Index (%) of Rice

The data pertaining to grains, straw, biological yield and harvest index are given in Table 9.

Table 8. Effect of irrigation scheduling and fertilizer management on yield attributes characters of Basmati rice

Treatments		Yield attributes			
		Panicle length (cm)	**No. of panicle**	**No. of grain/panicle**	**1000 grain weight (g)**
(A) Irrigation Scheduling					
I_1	IW/CPE 0.8 throughout the growth stage	22.3	126.7	136.5	21.2
I_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	22.7	128.5	138.9	22.3
I_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	23.5	132.1	150.6	23.7
I_4	IW/CPE 1.0 throughout growth stage	23.3	130.8	141.2	22.5
I_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	27.5	138.2	152.8	23.8
SE(m)±		***0.15***	***0.53***	***0.76***	***0.25***
C.D. (P=0.05)		***0.52***	***1.83***	***2.61***	***0.86***
(B) Fertilizer Management					
N_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	20.3	110.2	138.7	20.8
N_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	21.8	133.5	139.7	21.7
N_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	22.2	134.6	143.6	22.3
N_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	23.8	134.8	145.1	23.5
N_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	22.6	132.9	141.6	22.9
N_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	27.7	139.4	145.9	23.8
SE(m)±		***0.44***	***1.47***	***1.38***	***0.47***
C.D. (P=0.05)		***1.27***	***4.22***	***3.94***	***1.36***

3.6.1 Biological yield

It is evident from the Table 9, that the biological yield significantly differed with irrigation treatments. The biological yield increased with increase in level of irrigations. The significantly higher biological yield (115.86 q ha^{-1}) was recorded in treatment I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage), which was at par with I3 (IW/CPE 0.8 up to panicle stage and thereafter 1.2 up to dough stage), respectively. The significantly lowest biological yield (96.01 q ha^{-1}) was observed under treatment I1 (IW/CPE 0.8 throughout the growth stage). Similarly, the biological yield significantly varied with the fertility management treatments. The treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) obtained significantly higher biological yield (118.85 q ha^{-1}) which was statistically at par with the treatments N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) and N5 (150% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). The significantly lowest biological yield (91.62 q ha^{-1}) was found under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT).

3.6.2 Grain yield (q ha-1)

It is evident from the data given in Table 9, that the grain yield significantly varied with irrigation treatments. The maximum grain yield (47.32 q ha^{-1}) was recorded under the treatment I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage), which was at par with I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage), respectively. The significantly lowest grain yield (37.41 q ha^{-1}) was observed under the treatment I1 (IW/CPE 0.8 throughout the growth stage). It is clear from the results that grain yield significantly influenced due to the fertility management treatments. Amongst all the fertilizer treatments, the treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) obtained significantly higher grain yield, which was at par with N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) and N5 (150% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). The significantly lowest grain yield (36.88 q ha^{-1}) was recorded under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Keerthi et al (2018) studied that IW/CPE 1.0 up to panicle initiation stage and IW/CPE 1.2 up to dough stage recorded higher yield attributes, number of panicles $hill^{-1}$ (9.1), number of filled grains $panicle^{-1}$ (87.9), test weight (15.3 g), grain yield (4462 $kgha^{-1}$), straw yield (5977 $kgha^{-1}$) while Lower were recorded at IW/CPE 0.8 throughout the growth stage. Choudhary et al. (2016) recorded that highest grain yield of rice was recorded with the application of two irrigations-one each which was 7.96 and 10.73 per cent higher over one irrigation stage, respectively.

3.6.3 Straw yield (q ha-1)

It is evident from the Table 9, that the straw yield significantly differed with irrigation scheduling treatments. The straw yield increased with increase in levels of irrigations. The maximum straw yield (68.54 q ha^{-1}) was recorded in treatment I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage), which was at par with I3 (IW/CPE 0.8 up to panicle stage and thereafter 1.2 up to dough stage) and I4 (IW/CPE 1.0 throughout growth stage), respectively. The significantly lowest straw yield (58.60 q ha^{-1}) was observed under treatment I1 (IW/CPE 0.8 throughout the growth stage). It is evident from the results in the table that straw yield significantly varied with the fertility management treatments. The treatment N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) obtained significantly higher straw yield (70.07 q ha^{-1}) which was statistically at par with the treatments N4 (125% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT) and N5 (150% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). The significantly lowest straw yield (54.73 q ha^{-1}) was found under the treatment N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT). Choudhary et al. (2018) found highest grain (3370 $kgha^{-1}$), straw yield (6030 $kgha^{-1}$) with irrigation scheduled at Normal transplanting with recommended water management practice and found at par with irrigation at 2 days interval and decrease in grain and straw yield was at differential irrigation schedules which lead to greater sensitivity for leaf area and tillers production.

3.6.4 Harvest index (%)

The data regarding the effect of different treatments on harvest index are shown in Table 9. Harvest index was affected non-significant by various treatment including irrigation scheduling and fertility management treatments. Among the harvest index the highest harvest index was recorded in I5 (IW/CPE 1.0 up to panicle initiation stage and thereafter IW/CPE 1.2 up to dough stage), which was significantly higher than the all other treatments. The lowest harvest index was

Table 9. Effect of irrigation scheduling and fertilizer management on yield and harvest index of Basmati rice

Treatments		Yield (q ha-1)`			
		Grain	**Straw**	**Biological**	**Harvest index (%)**
(A) Irrigation Scheduling					
I_1	IW/CPE 0.8 throughout the growth stage	37.41	58.60	96.01	38.96
I_2	IW/CPE 0.8 upto panicle initiation stage & thereafter IW/CPE 1.0 upto dough stage	43.10	65.04	108.14	39.86
I_3	IW/CPE 0.8 upto panicle stage and thereafter 1.2 upto dough stage	45.37	67.31	112.68	40.26
I_4	IW/CPE 1.0 throughout growth stage	42.18	66.25	108.43	38.90
I_5	IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage	47.32	68.54	115.86	40.84
SE(m)±		***0.91***	***0.93***	***1.15***	***0.52***
C.D. (P=0.05)		***2.72***	***3.23***	***3.98***	***NS***
(B) Fertilizer Management					
N_1	100% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	36.88	54.73	91.62	40.24
N_2	100% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	40.10	61.87	101.97	39.35
N_3	125% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	42.56	64.25	106.82	39.83
N_4	125% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	47.26	69.26	116.53	40.59
N_5	150% RDN : 4 equal splits at 15, 30, 45 & 60 DAT	45.16	68.58	113.75	39.68
N_6	150% RDN : 5 equal splits at 15, 25, 35, 45 & 60 DAT	48.78	70.07	118.85	40.95
SE(m)±		***1.41***	***1.66***	***2.19***	***0.84***
C.D. (P=0.05)		***4.20***	***4.74***	***6.26***	***NS***

recorded in I1 (IW/CPE 0.8 throughout the growth stage). Among the fertility management treatments highest harvest index was recorded in N6 (150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT).

The lowest harvest index recorded in N1 (100% RDN: 4 equal splits at 15, 30, 45 & 60 DAT) treatment.

4. CONCLUSION

On the basis of experimental findings it is clear that maximum crop yield and benefit cost ratio was achieved with IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage. Among the fertility management treatments, the highest crop yield was recorded with the application of 150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT. Thus, it may be concluded that application of IW/CPE 1.0 upto panicle initiation stage and thereafter IW/CPE 1.2 upto dough stage and150% RDN: 5 equal splits at 15, 25, 35, 45 & 60 DAT seems to best option for achieving higher yield and net returns of rice crop.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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