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Effect of irrigation scheduling and fertigation on performance of drip irrigated direct seeded rice (*Oryaza sativa* L)

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Abstract
A field experiment was conducted during *kharif* sessions of 2016 and 2017 at Agricultural Research Station (ARS), Gangavathi, UAS, Raichur, to study the effect of irrigation scheduling and fertigation on performance of drip irrigated direct seeded rice in clay soil. The experiment laid out in split plot design with four irrigation scheduling based on IW/CPE ratios assigned to main plots and four drip fertigation levels were allocated in subplots and replicated thrice. Irrigation scheduling at 1.50 IW/CPE ratio recorded significantly higher grain yield on average of two years (5060 kg ha^{-1}), straw yield (5937 kg ha^{-1}) and harvest index (0.46) but it was on par with 1.25 IW/CPE ratio (4875 kg ha^{-1}, 5593 kg ha^{-1} and 0.47, respectively). Among the drip fertigation levels, drip fertigation at 125% RDN recorded (5049 kg ha^{-1}, 5897 kg ha^{-1} and 0.46, respectively) followed by 100 RDN (4914 kg ha^{-1}, 5651 kg ha^{-1} and 0.46, respectively). Among the interaction, irrigation scheduling at 1.50 IW/CPE ratio with 125% RDN recorded significantly higher growth, yield and yield attributes than the other treatment combinations.

Keywords: IW/CPE ratio, Fertigation, irrigation scheduling, DSR

Introduction

Rice (*Oryza sativa* L.) is one of the most ancient food crops and a primary food source for over one third of the world's population being cultivated in 117 countries across the world and hence called as 'global cereal'. It is one of the oldest domesticated crops known to mankind with farmers having grown it under irrigated condition for more than 4,000 years. In India, it is a staple food for over two thirds of the population and is cultivated in an area of 43.44 million ha with a production of 112.40 million tons and productivity of 2.70 tons ha^{-1} (Anon., 2017) and in Karnataka, rice occupies an area of 2.52 million ha with an annual production of 3.92 million tons and a productivity of 2.72 tons per ha (Anon., 2017)., therefore, is a means of livelihood for millions of rural households and plays a vital role in our national food security and hence the slogan "Rice is Life" is most appropriate.

Food security of India is of utmost importance to its foreign policy but the issue of food security is still a live issue. Hence there is need to produce 270 million tons to feed the increasing population. This additional rice will have to come from the existing land with less usage of water, labour and chemicals (Zhang *et al.*, 2009) [12]. The global water crisis is due to failure of monsoon and adoption of efficient ground water extraction technologies, leading to depletion of ground water table, polluted and damaged ecosystem which is threatening the sustainability of irrigated rice production.

Further, water becomes a scarce resource due to increased demand for industrial, agricultural and domestic purposes, besides increased cost on fertilizer necessitated for development and adoption of alternative agro techniques which help in effective and efficient utilization of these inputs. In this context use of micro irrigation techniques and fertigation is the only way to manage water and nutrient resources efficiently.

Drip irrigation, also known as trickle irrigation is an irrigation method that applies water slowly to the root zone of plants, through a network of valves, pipes, tubes and emitters. The goal is to optimize water and input usage. Adoption of micro irrigation might help in increasing the irrigated area, productivity of crops and water use efficiency (Sivanappan, 2004) [10]. Direct seeded rice with drip irrigation can address the multi facet problems of water scarcity, weed competition and environmental pollution.

When the rice cultivation is shifted from TPR to DSR, weeds pose major threat to rice production. Under such scenario micro-irrigation /drip irrigation plays important role in restricting weed flora apart from regular supply of required amount of moisture for DSR growth and development. Therefore, present field investigation was planned to study the effect irrigation scheduling and fertigation on fertigation on performance of drip irrigated direct seeded rice (*Oryaza sativa* L.) under semi arid tropics of Karnataka region.

Material and Methods

Field experiments were conducted at Agricultural Research Station (ARS), Gangavathi, University of Agricultural Sciences (UAS), Raichur, Karnataka during *kharif* seasons of 2016 and 2017 at clay soil. The soil had average 0.55% organic carbon, 276.20 kg ha^{-1} nitrogen, 54.31 kg ha^{-1} phosphorus and 265.57 kg ha^{-1} potassium in medium range available nutrients. The experiment was laid out in split plot design replicated thrice. The treatment comprised four irrigation scheduling based on IW/CPE ratios (D) *viz.,* D_1-0.75, D_2-1.00, D_3-1.25 and D_4-1.50 assigned as main plots. Each main plot were further divided in to four sub plots i.e. fertigation levels (F) *viz.,* F_1-75% RDN, F_2-100% RDN, F_3-125% RDN and F_4-100% RDF through surface application. Recommended dose of fertilizer, i.e. 150:60:50 kg ha^{-1} N: P_2O_5: K_2O, respectively in DSR.

Fertigation

Fertigation was done through ventury system to each plot up to 100 days after sowing as per the treatment details. Fertilizer solution was filled in plastic bucket and connected with suction device of ventury. Fertigation of nitrogen was through urea fertilizer. Phosphorus and potassium applied as basal dose in the form of diamine phosphate (DAP) and murate of potash (MOP), respectively. Fertigation schedule was started one week after sowing. Out of total nutrients, 50 per cent N and the entire dose of P and K were applied as basal and remaining 50 per cent N was fertigated in 5 equal splits at 10 days interval. Micronutrient spray was also given uniformly to all experiments. In conventional fertilizer method, fertilizers were applied in the form urea, DAP and MOP.

Optimum plant population was maintained by thinning excess seedling leaving one seedling per hill. Healthy crop stand was ensured by adopting need based plant protection and recommended package of practices. Five plants were selected at random and tagged. These plants were used for recording number of tillers, leaf area and leaf area index. Yield and its components were recorded at the time of harvest. Numbers of productive tillers $hill^{-1}$, panicle length, panicle weight, grains $panicle^{-1}$, 1000 grain weight and harvest index were recorded based on the method of Yoshida and Alexander (1970) [11].

The cost of cultivation was computed by considering the prevailed prices of input market price for rice and straw. The cost of cultivation was deducted from gross returns to arrive at net returns. Benefit cost ratio was worked out by taking the ratio of grass returns to total cost of cultivation.

Gross return = [Grain yield x market price of grain] + [straw yield x market price of straw]

Net returns = Gross returns – total cost of cultivations

$$\text{Benefit Cost Ratio} = \frac{\text{Gross returns (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

$$\text{Harvest index} = \frac{\text{Grain yield (kg ha}^{-1})}{\text{Biological yield (kg ha}^{-1})}$$

The experimental data collected on growth and yield components of crop was subjected to Fisher's method of "Analysis of Variance" (ANOVA) as outlined by Panse and Sukhatme (1967) at 5% level of probability. Wherever, F- test was significant an appropriate value of critical difference (C.D.) was used for comparison of the treatment means, otherwise, 'NS' (Non-significant) was indicated against C.D. values. All the data including economics were statistically analysed and interpreted. The Duncan's multiplication range test (DMRT) was carried out with MSTAC software.

Results and Discussion

Growth Parameters

The data on growth components (Table 1 and fig.1) *viz*., plant height, number of tillers and total dry matter production at harvest, no. of leaves per plant, leaf area and leaf area index at 90 DAS as influenced by IW/CPE ratio, fertigation levels and there combination of direct seeded rice (DSR).

Among methods of IW/CPE ratios, irrigation scheduling at 1.50 IW/CPE ratio (D_4 recorded significantly taller plants (98.65cm), number of tillers (774), total dry matter accumulation (121.39 g $plant^{-1}$) at harvest on pooled basis and number of leaves (47.3 $plant^{-1}$), leaf area (1539.3 cm^2 $plant^{-1}$) and leaf area index (7.70) at 90 DAS on pooled basis followed by 1.25 IW/CPE ratio (96.79 cm, 703 m^{-2} and 112.38 g at harvest respectively on pooled basis and 42.3 $plant^{-1}$, 1345.1 cm^2 $plant^{-1}$ and 6.73, respectively at 90 DAS on pooled basis) and significantly lower plant height was registered in 0.75 IW/CPE ratio (90.72 cm, 606 m^{-2} and 92.69 g $plant^{-1}$, respectively at harvest on pooled basis and 29.9 $plant^{-1}$, 825.4 cm^2 $plant^{-1}$ and 4.13, respectively at 90 DAS on pooled basis) in DSR.

It might be due to maintenance of adequate soil moisture by frequent irrigation which favoured faster cell division and cell elongation ultimately resulting in higher tiller production, more number of leaves and leaf area development and also higher dry matter production. Similar results were obtained by Anitta *et al.* (2011) [1] and Anusha (2015) [3].

Recommended dose of nitrogen (RDN) at 125 % and P & K basal (F_3) recorded significantly higher plant height (98.36 cm), number of tillers (779 m^{-2}) and total dry matter production (130.59 g $plant^{-1}$) at harvest, respectively on pooled basis and number of leaves (45.5 $plant^{-1}$), leaf area (1621.9 cm^2 $plant^{-1}$) and leaf area index (8.11) at 90 DAS, respectively on pooled basis closely followed by RDN and P & K basal (F_2) (96.64 cm, 724 m^{-2} and 115.24 g $plant^{-1}$ at harvest, respectively on pooled basis and 42.3 $plant^{-1}$,1401.3 cm^2 $plant^{-1}$ and 7.01, at 90 DAS, respectively on pooled basis), while lower growth parameters recorded with RDF through surface application (F_4) (91.88 cm, 610 m^{-2} and 81.55 g $plant^{-1}$ at harvest, respectively on pooled basis and 32.9 $plant^{-1}$, 867.0 cm^2 $plant^{-1}$ and 4.34, at 90 DAS, respectively on pooled basis).

Higher yield and yield attributes was result of direct seeded rice under drip irrigation recorded higher leaf area and leaf area index. This might have helped in higher dry matter production and accumulation due to higher photosynthetic activity. The plants having optimum moisture content and having higher turgidity led to maximum stomatal aperture opening with minimal stomatal resistance. Similar results were found in Anusha (2015) [3] and Jagadish (2015) [7].

Interaction between drip irrigation scheduling at IW/CPE ratio and drip fertigation level revealed higher growth parameters with 1.50 IW/CPE ratio X fertigation at 125 % RDN (D_4F_3) plant height (101.67 cm), number of tillers (861 m^{-2}) and total dry matter production (145.01 g $plant^{-1}$) at harvest, respectively on pooled basis and number of leaves (54.7 $plant^{-1}$), leaf area (2033.6 cm^2 $plant^{-1}$) and leaf area index (10.17) at 90 DAS, respectively on pooled basis and all fertigation level (F_{1-3}) with D_2 and D_3 were at par, while lower plant height throughout among all was observed with 0.75 IW/CPE ratio X 100 % RDF through surface application (D_1F_4) (85.96 cm, 501 m^{-2} and 69.92 g $plant^{-1}$ at harvest, respectively on pooled basis and 24.3 $plant^{-1}$, 520.4 cm^2 $plant^{-1}$ and 2.53, at 90 DAS, respectively on pooled basis). Other combinations fell in between.

Higher yield was attributed to higher plant height, number of tillers and dry matter accumulation which helped in higher dry matter production and accumulation due to higher photosynthetic activity resulting in production of higher leaf area, LAI and LAD because of continuous and optimum availability of soil moisture and nutrients which in turn improved yield contributing characters like number of productive tillers $hill^{-1}$, panicle length and number of grains $panicle^{-1}$ and 1000-grain weight. Similar results were made by Anusha (2015) [3].

Table 1: Effect of Irrigation scheduling based (IW/CPE ratios) and fertilizer levels on growth of drip irrigated direct seeded rice (pooled data 2016 and 2017)

Treatments	**At harvest**			**At 90 DAS**		
	Plant Height (cm)	**Number of tillers ($plant^{-1}$)**	**Total dry matter accumulation (g)**	**Number of leaves ($plant^{-1}$)**	**Leaf area (cm^2 $plant^{-1}$)**	**LAI**
IW/CPE ratio (D)						
D_1	90.72^{b}	606^{c}	92.69^{d}	29.9^{c}	825.4^{d}	4.13^{d}
D_2	93.96^{ab}	647^{c}	103.58^{c}	38.3^{b}	1139.1^{c}	5.70^{c}
D_3	96.79^{a}	703^{b}	112.38^{b}	42.3^{a}	1345.1^{b}	6.73^{b}
D_4	98.65^{a}	774^{a}	121.39^{a}	47.3^{a}	1539.3^{a}	7.70^{a}
S.Em±	0.87	14	2.40	2.3	52.3	0.26
Fertigation (F)						
F_1	93.23^{b}	618^{c}	102.67^{c}	37.1^{bc}	958.8^{b}	4.79^{b}
F_2	96.64^{a}	724^{b}	115.24^{b}	42.3^{ab}	1401.3^{a}	7.01^{a}
F_3	98.36^{a}	779^{a}	130.59^{a}	45.5^{a}	1621.9^{a}	8.11^{a}
F_4	91.88^{b}	610^{c}	81.55^{d}	32.9^{c}	867.0^{b}	4.34^{b}
S.Em±	0.70	15	1.35	1.8	76.9	0.38
Interaction (D X F)						
D_1F_1	88.42^{de}	556^{hi}	89.10^{hi}	29.7^{ef}	692.4^{gh}	3.46^{gh}
D_1F_2	93.34^{b-d}	655^{e-g}	99.55^{fg}	31.6^{d-f}	982.4^{d-h}	4.91^{e-h}
D_1F_3	95.17^{a-d}	713^{c-f}	112.18^{de}	34.0^{c-f}	1121.8^{c-g}	5.61^{d-g}
D_1F_4	85.96^{e}	501^{i}	69.92^{k}	24.3^{f}	505.1^{h}	2.53^{h}
D_2F_1	92.13^{b-e}	579^{g-i}	99.31^{fg}	35.0^{b-f}	940.2^{d-h}	4.70^{f-h}
D_2F_2	96.31^{a-c}	685^{d-f}	111.99^{de}	41.2^{b-f}	1317.0^{b-f}	6.58^{c-f}
D_2F_3	97.15^{a-c}	756^{b-d}	124.63^{bc}	45.2^{a-d}	1473.9^{a-d}	7.37^{b-e}
D_2F_4	90.23^{c-e}	567^{g-i}	78.39^{j}	31.8^{d-f}	825.5^{f-h}	4.13^{f-h}
D_3F_1	95.50^{a-d}	656^{e-g}	106.41^{ef}	38.1^{b-f}	983.3^{e-h}	4.92^{e-h}
D_3F_2	97.61^{a-c}	739^{b-d}	120.10^{cd}	46.4^{a-d}	1520.1^{a-e}	7.60^{b-d}
D_3F_3	99.47^{ab}	785^{a-c}	140.52^{a}	48.2^{ab}	1858.2^{ab}	9.29^{ab}
D_3F_4	94.57^{a-d}	634^{f-h}	82.49^{ij}	36.4^{b-f}	1019.0^{c-g}	5.09^{d-g}
D_4F_1	96.86^{a-c}	681^{d-f}	115.84^{d}	45.7^{a-c}	1219.4^{c-g}	6.10^{d-f}
D_4F_2	99.31^{ab}	817^{ab}	129.29^{b}	49.8^{ab}	1785.6^{a-c}	8.93^{a-c}
D_4F_3	101.67^{a}	861^{a}	145.01^{a}	54.7^{a}	2033.6^{a}	10.17^{a}
D_4F_4	96.76^{a-c}	737^{b-e}	95.41^{gh}	39.1^{a-d}	1118.5^{c-g}	5.59^{d-g}
S.Em±	1.39	30	2.71	3.5	153.8	0.77

Note: The means with same alphabet do not differ significantly under DMRT
Main plots: IW/CPE ratio (D)
D_1- 0.75 IW/CPE ratio D_2- 1.00 IW/CPE ratio
D_3- 1.25 IW/CPE ratio D_4- 1.50 IW/CPE ratio
Sub plots: Fertigation level (F)
F_1- 75 % RDN F_2- 100 % RDN
F_3- 125 % RDN F_4- 100 % RDF through surface application
DAS- Days after sowing

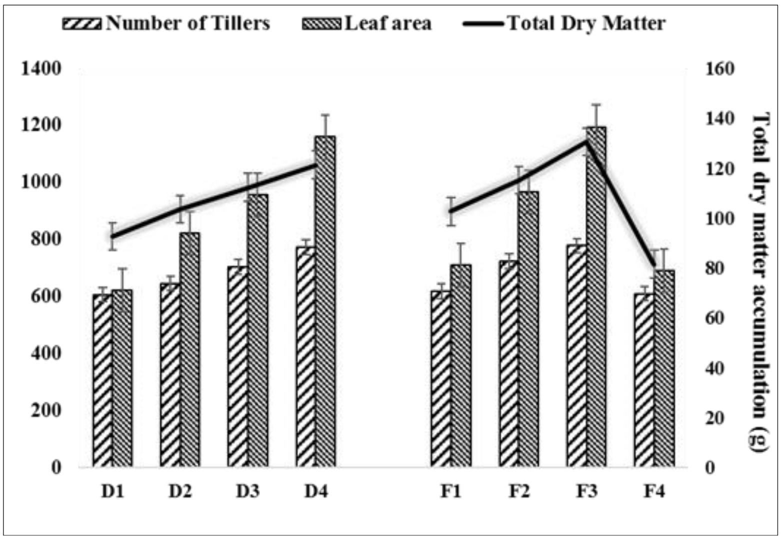

Fig 1: Number of tillers, leaf area and total dry matter accumulation as influenced by different IW/CPE ratios and fertigation levels in drip irrigated DSR

Yield and yield attributes

Irrigation scheduling based on IW/CPE ratio, drip fertigation level and their combination (Table 2 and fig. 2) had significant influence on yield and yield attributes during both the years and on pooled basis as well. Among the IW/CPE ratio, 1.50 IW/CPE ratio recorded the highest grain yield (5060 kg ha^{-1}), straw yield (5937 kg ha^{-1}) and harvest index (0.46) and yield attributes viz., number of panicle 10.92 $plant^{-1}$, panicle weight (13.89 g), total grains 140.3 $panicle^{-1}$ and test weight (25.33 g) on pooled basis followed by 1.25 IW/CPE ratio (4875 kg ha^{-1}, 5593 kg ha^{-1} and 0.47, respectively on pooled basis) and yield attributes (10.30 $plant^{-1}$, 12.62 g, 130.5 $panicle^{-1}$ and 24.03 g, respectively on pooled basis) which were on par with each other and whereas 0.75 IW/CPE ratio (D_1) recorded significantly lower grain yield (4431 kg ha^{-1}, 5074 kg ha^{-1} and 0.47, respectively on pooled basis) and yield attributes (8.01 $plant^{-1}$, 11.45 g, 121.1 $panicle^{-1}$ and 23.08 g, respectively on pooled basis).

These improvements with 1.50 IW/CPE ratio might be due to the continuous and uninterrupted moisture supply throughout the crop growth period which resulted in increased moisture and besides higher cell division and elongation. The soil water distribution under drip irrigation is vertical in the beginning but later there will be a lateral distribution whereas, distribution remained primarily vertical under surface irrigation (Araujo *et al.*, 1995). This resulted in low soil suction, better water and nutrient uptake by plants under higher IW/CPE of drip irrigation. Zheng *et al*. (2004) opined that the higher number of leaves, leaf area and leaf area index were positively contributed to higher dry matter production.

Among the fertigation levels, 125% RDN and P & K basal (F_3) fared superior to other fertigation levels and recorded the highest grain yield (5205 kg ha^{-1}), straw yield (5897 kg ha^{-1}) and harvest index (0.46) on pooled basis and yield attributes *viz.*, number of panicle 12.34 $plant^{-1}$, panicle weight 14.93 g, total grains 139.5 $panicle^{-1}$ and test weight 24.81 g, respectively on pooled basis. 100% RDN and P & K basal (F_2) was next in the order (4914 kg ha^{-1}, 5651 kg ha^{-1} and 0.46, respectively on pooled basis) and yield attributes (11.05 $plant^{-1}$, 12.97 g, 133.7 $panicle^{-1}$ and 24.27 g, respectively on pooled basis) and was comparable to the F_3 during individual years, while, 100% RDF through surface application (F_4) recorded the lowest yield (4324 kg ha^{-1}, 5072 kg ha^{-1} and 0.46, respectively on pooled basis) and yield attributes (7.03 $plant^{-1}$, 11.25 g, 121.6 $panicle^{-1}$ and 23.31 g, respectively on pooled basis).

Frequent dressings of N through drip irrigation coincided well with the actual needs of crop thereby favoured growth ultimately resulting in yield improvement, while surface application failed to match the real-time demand of nutrients and hence adversely affected yield (Binder *et al.*, 2000). Moreover, there was increased solubility and availability of nutrients in the root zone in case of fertigation. Similar results were reported by Gouri *et al.*, 2012.

Among the interactions, 1.50 IW/CPE ratio X 125% RDN and P & K basal (D_4F_3) stood out among all recording higher grain yield (5478 kg ha^{-1}), straw yield (6520 kg ha^{-1}) and harvest index (0.46) on pooled basis and yield attributes viz., number of panicle (13.99 $plant^{-1}$), panicle weight (16.81 g), total grains (151.7 $panicle^{-1}$) and test weight (26.11 g) on pooled basis closely followed by 1.50 IW/CPE ratio X 100% RDN and P & K basal (D_4F_2-5184 kg ha^{-1}, 6052 kg ha^{-1} and 0.46, respectively on pooled basis) and yield attributes (11.97 $plant^{-1}$, 13.87 g, 143.4 panicle-1 and 25.51 g, respectively on pooled basis) and D_3F_3 (5215 kg ha^{-1}, 5974 kg ha^{-1} and 0.47, respectively on pooled basis) and yield attributes (12.82 $plant^{-1}$, 14.70 g, 138.0 $panicle^{-1}$ and 24.64 g, respectively on pooled basis) which were on par with former treatment combination, while lower yield (4121 kg ha^{-1}, 4720 kg ha^{-1} and 0.47, respectively on pooled basis) and yield attributes (4.84 $plant^{-1}$, 9.77 g, 109.0 $panicle^{-1}$ and 21.92 g, respectively on pooled basis) was recorded with 0.75 IW/CPE ratio X 100% RDF through surface application (D_1F_4).

Yield improvement in rice under drip fertigation and they attributed it to the maintenance of soil near field capacity throughout the growth period in the active root zone, leading to low soil suction, which facilitated better water utilization, higher nutrients uptake and excellent maintenance of soil-water-plant relationship with higher oxygen concentration in the root zone (Pramanik *et al.* 2014).

Table 2: Effect of Irrigation scheduling based (IW/CPE ratios) and fertilizer levels on yield and yield attributes of drip irrigated direct seeded rice (pooled data 2016 and 2017)

Treatments	**Yield (kg ha^{-1})**		**Harvest Index**	**Yield attributes**			
	Grain	**Straw**		**Number of Panicle (m^{-2})**	**Panicle weight (g)**	**Total filled grains (panicle^{-1})**	**Test weight (g)**
IW/CPE ratio (D)							
D_1	4431^{b}	5074^{c}	0.47^{a}	8.01^{c}	11.45^{b}	121.1^{b}	23.08^{c}
D_2	4599^{b}	5360^{bc}	0.46^{a}	9.23^{b}	12.59^{ab}	128.5^{b}	23.68^{bc}
D_3	4875^{a}	5593^{ab}	0.47^{a}	10.30^{bc}	12.62^{ab}	130.5^{ab}	24.03^{ab}
D_4	5060^{a}	5937^{a}	0.46^{a}	10.92^{a}	13.89^{a}	140.3^{a}	25.33^{a}
S.Em±	58	119	--	0.36	0.45	2.9	0.21
Fertigation (F)							
F_1	4678^{b}	5343^{b}	0.47^{a}	8.05^{b}	11.41^{bc}	125.6^{b}	23.73^{bc}
F_2	4914^{ab}	5651^{a}	0.46^{a}	11.05^{b}	12.97^{b}	133.7^{a}	24.27^{ab}
F_3	5049^{a}	5897^{a}	0.46^{a}	12.34^{a}	14.93^{a}	139.5^{a}	24.81^{a}
F_4	4324^{c}	5072^{b}	0.46^{a}	7.03^{c}	11.25^{c}	121.6^{b}	23.31^{c}
S.Em±	90	104	0.01	0.43	0.57	2.0	0.26
Interaction (D X F)							
D_1F_1	4363^{f-h}	4996de	0.47^{a}	6.23^{hi}	9.93^{a}	116.2^{ef}	22.89^{ef}
D_1F_2	4583^{d-f}	5163^{c-e}	0.47^{a}	9.82^{c-g}	12.51^{bc}	126.6^{c-e}	23.40^{c-f}
D_1F_3	4656^{d-f}	5415^{b-e}	0.46^{a}	11.16^{b-f}	13.60^{a-c}	132.7^{b-d}	24.10^{b-e}
D_1F_4	4121^{h}	4720^{e}	0.47^{a}	4.84^{i}	9.77^{c}	109.0^{f}	21.92^{f}
D_2F_1	4501^{e-g}	5186^{c-e}	0.47^{a}	8.31^{f-h}	11.40^{bc}	122.9^{de}	23.29^{c-f}
D_2F_2	4778de	5576^{b-d}	0.46^{a}	10.62^{bf}	13.22^{a-c}	133.6^{b-d}	23.94^{b-e}
D_2F_3	4747^{cd}	5677^{b-d}	0.46^{a}	11.40^{a-e}	14.59^{ab}	135.7^{b-d}	24.38^{a-e}
D_2F_4	4270^{gh}	5002de	0.46^{a}	6.60^{hi}	11.16^{bc}	122.0^{de}	23.12^{d-f}
D_3F_1	4777de	5408^{b-e}	0.47^{a}	9.00^{d-h}	11.80^{bc}	128.2^{c-e}	23.79^{b-e}
D_3F_2	5110^{bc}	5814^{bc}	0.47^{a}	11.77^{a-d}	12.28^{bc}	131.3^{b-d}	24.24^{b-e}
D_3F_3	5215^{b}	5974^{ab}	0.47^{a}	12.82^{ab}	14.70^{ab}	138.0^{bc}	24.64^{a-d}
D_3F_4	4397^{f-h}	5175^{c-e}	0.46^{a}	7.61^{gh}	11.72^{bc}	124.4^{c-e}	23.47^{c-f}
D_4F_1	5070^{bc}	5785^{bc}	0.47^{a}	8.65^{e-h}	12.52^{bc}	135.1^{b-d}	24.95^{a-c}
D_4F_2	5184^{b}	6052^{ab}	0.46^{a}	11.97^{a-c}	13.87^{ab}	143.4^{ab}	25.51^{ab}
D_4F_3	5478^{a}	6520^{a}	0.46^{a}	13.99^{a}	16.81^{a}	151.7^{a}	26.11^{a}
D_4F_4	4507^{e-g}	5391^{b-e}	0.45^{a}	9.06^{d-h}	12.35^{bc}	130.9^{b-d}	24.74^{a-d}
S.Em±	180	207	0.01	0.86	1.14	4.0	0.51

Note: The means with same alphabet do not differ significantly under DMRT
Main plots: IW/CPE ratio (D)
D_1- 0.75 IW/CPE ratio D_2- 1.00 IW/CPE ratio
D_3- 1.25 IW/CPE ratio D_4- 1.50 IW/CPE ratio
Sub plots: Fertigation level (F)
F_1- 75 % RDN F_2- 100 % RDN
F_3- 125 % RDN F_4- 100 % RDF through surface application

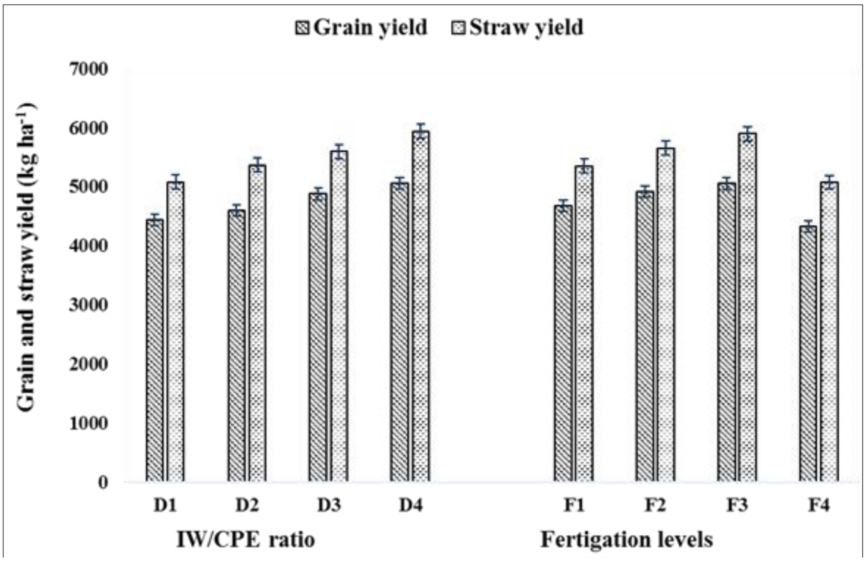

Fig 2: Grain yield and straw yield as influenced by different IW/CPE ratios and fertigation levels in drip irrigated DSR

Economic Parameters

The economics of production (Table 3) as influenced by different IW/CPE ratios and fertigation levels and their interaction, the variations in cost of cultivation, gross returns, net return and B:C ratio as influenced by irrigation scheduling practices, fertigation levels and their interactions revealed significant differences during both the years' of experimentation and on pooled basis as well.

Among the irrigation levels, 1.5 IW/CPE (D_4) recorded significantly higher cost of cultivation (₹ 40116 ha^{-1}), gross returns (₹ 85220 ha^{-1}), net return (₹ 45105 ha^{-1}) and B:C ratio (2.12) on pooled basis closely followed by 1.25 IW/CPE (₹ 39740 ha^{-1}, ₹ 82064 ha^{-1}, ₹ 42324 ha^{-1} and 2.06, respectively on pooled basis) which was on par, while remaining levels were comparable but recorded lower economical parameters (₹ 39355 ha^{-1}, ₹ 74579 ha^{-1}, ₹ 35589 ha^{-1} and 1.91, respectively on pooled basis) in 0.75 IW/CPE ratio. This might be due to lower quantity of water used in lower ratios while in 1.50 and 1.25 ratios water applied was higher which influenced WUE and water productivity. Results are in conformity with Anusha (2015) [3] and Jagadish (2015) [7].

While among the fertigation scheduling practices, 125% RDN (F_3) registered the maximum cost of cultivation (₹ 39815 ha^{-1}), gross returns (₹ 85046 ha^{-1}), net return (₹ 45231 ha^{-1}) and B:C ratio (2.13) on pooled basis closely followed by fertigation of RDN (₹ 39571 ha^{-1}, ₹ 82728 ha^{-1}, ₹ 43157 ha^{-1} and 2.09, respectively on pooled basis) which was on par, while the lowest parameters (₹ 39496 ha^{-1}, ₹ 72833 ha^{-1}, ₹ 33336 ha^{-1} and 1.84, respectively on pooled basis) were recorded with traditional surface broadcast application of RDN (F_4) followed by lower dose of N of 75% RDN through fertigation. Higher returns with the former treatment was primarily due to higher yield. Lowest net returns were obtained with surface application of fertilizers. Similar results are reported by Anusha (2015) [3]

Among the treatment combinations, it was 1.50 IW/CPE X 125% RDN (D_4F_3) fared superior to all and recorded the maximum cost of cultivation (₹ 40378 ha^{-1}), gross returns (□ 92315 ha^{-1}), net return (₹ 51937 ha^{-1}) and B:C ratio (2.29) on pooled basis closely followed by 1.25 IW/CPE X 125% RDN (₹ 40003 ha^{-1}, ₹ 87802 ha^{-1}, ₹ 47799 ha^{-1} and 2.19, respectively on pooled basis) and 1.50 IW/CPE X fertigation of RDN (D_4F_2) (₹ 40134 ha^{-1}, ₹ 87313 ha^{-1}, ₹ 47179 ha^{-1} and 2.17, respectively on pooled basis) which were on par with the former treatment combination (D_4F_3), while 0.75 IW/CPE X surface application of RDN (D_1F_4) recorded significantly lower economic parameters (₹ 38934 ha^{-1}, ₹ 69367 ha^{-1}, ₹ 30434 ha^{-1} and 1.78, respectively on pooled basis) among all followed by 1.00 IW/CPE X surface application of RDN. Higher benefits with the former treatment combination were primarily due to higher yield rather than cost of production. Lower net returns were obtained with surface application of fertilizers

Table 3: Effect of Irrigation scheduling based (IW/CPE ratios) and fertilizer levels on economics of drip irrigated direct seeded rice (pooled data 2016 and 2017)

Treatments	₹. ha^{-1}			B:C ratio
	Cost of cultivation	Gross income	Net income	
IW/CPE ratio (D)				
D_1	38990 ^{a}	74579^{b}	35589^{b}	1.91^{c}
D_2	39365 ^{a}	77458^{b}	38093^{b}	1.97^{bc}
D_3	39740 ^{a}	82064^{a}	42324^{a}	2.06^{ab}
D_4	40116 ^{a}	85220^{a}	45105^{a}	2.12^{a}
S.Em±	--	988	988	0.03
Fertigation (F)				
F_1	39328 ^{a}	78714 ^{b}	39386^{b}	2.00^{b}
F_2	39571 ^{a}	82728^{ab}	43157^{ab}	2.09^{ab}
F_3	39815 ^{a}	85046^{a}	45231^{a}	2.13^{a}
F_4	39496 ^{a}	72833^{c}	33336^{c}	1.84^{c}
S.Em±	--	1478	1478	0.04
Interaction (D X F)				
D_1F_1	38765 ^{a}	73436^{ef}	34672^{d-f}	1.89^{d-g}
D_1F_2	39009 ^{a}	77111^{c-f}	38102^{b-f}	1.98^{b-g}
D_1F_3	39252 ^{a}	78400^{b-f}	39148^{b-f}	2.00^{b-g}
D_1F_4	38934 ^{a}	69367^{f}	30434^{f}	1.78^{g}
D_2F_1	39140 ^{a}	75777^{d-f}	36637^{c-f}	1.94^{b-g}
D_2F_2	39384 ^{a}	80474^{b-e}	41090^{b-e}	2.04^{a-g}
D_2F_3	39628 ^{a}	81667^{b-e}	42039^{b-e}	2.06^{a-f}
D_2F_4	39309 ^{a}	71913^{ef}	32604^{ef}	1.83^{fg}
D_3F_1	39515 ^{a}	80362^{b-e}	40847^{b-e}	2.03^{a-g}
D_3F_2	39759 ^{a}	86014^{a-e}	46255^{a-d}	2.16^{a-d}
D_3F_3	40003 ^{a}	87802^{ab}	47799^{d-f}	2.19^{ab}
D_3F_4	39684 ^{a}	74079^{ef}	34395^{ab}	1.87^{e-g}
D_4F_1	39891 ^{a}	85281^{a-d}	45390^{a-c}	2.14 $^{a-e}$
D_4F_2	40134 ^{a}	87313^{ab}	47179^{ab}	2.17^{a-e}
D_4F_3	40378 ^{a}	92315^{a}	51937^{a}	2.29^{a}
D_4F_4	40059 ^{a}	75972^{d-f}	35913^{c-f}	1.90^{c-g}
S.Em±	--	2955	2955	0.07

Note: The means with same alphabet do not differ significantly under DMRT

Main plots: IW/CPE ratio (D)

D_1- 0.75 IW/CPE ratio D_2- 1.00 IW/CPE ratio

D_3- 1.25 IW/CPE ratio D_4- 1.50 IW/CPE ratio

Sub plots: Fertigation level (F)

F_1- 75 % RDN F_2- 100 % RDN

F_3- 125 % RDN F_4- 100 % RDF through surface application

Conclusion

1.50 IW/CPE ratio, fertigation of 125% RDN and 1.50 IW/CPE ratio with 125% RDN interaction recorded significantly higher growth parameters *viz*., plant height, total dry matter production, leaf area and leaf area index as compared to other IW/CPE ratios. Significantly higher grain yield and straw yield compared to 1.00 IW/CPE ratio and yield attributes, higher number of panicles plant^{-1}, panicle length, panicle weight, total grains and test weight as compared other IW/CPE ratios and 100% RDF through surface application. 1.50 IW/CPE ratio and 125% RDN fetched significantly higher gross, net returns and B:C ratio followed by 1.25 IW/CPE ratio and 125% RDN, whereas lower economics outcome in 0.75 IW/CPE ratio and 100% RDF through surface application. Among the interaction combination 1.50 W/CPE ratio with 125% RDN outcome as superior and 0.75IW/CPE ratio with 100% RDF through surface application was lower economical outcome.

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