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EFFECT OF IRRIGATION AND NUTRIENT MANAGEMENT ON GROWTH, YIELD AND EVAPOTRANSPIRATION OF DIRECT-SEEDED AUTUMN RICE (*ORYZA SATIVA*) UNDER THE AGRO-CLIMATIC CONDITIONS OF ASSAM

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ABSTRACT
An experiment was conducted at the Instructional-cum-Research Farm, Assam Agricultural University, Jorhat, during two consecutive summers (Feb-June) seasons of 2017 and 2018. The experiment was laid out in a split-plot design with 3 replications to evaluate the growth, yield and evapotranspiration of rice under moisture and nutrient management practices. Among the 4 irrigation regimes, superior growth (Plant height (23.27% and 22.77%), dry matter accumulation (23.15% and 23.45%) and number of tillers (40.96% and 46.88%)), grain yield (32.90% and 36.22%) and evapotranspiration (12.54% and 29.82%) observed under IW:CPE=1.60 in both the year as compared to rainfed. Among the 5 nutrient management practices, 50% N of RDF + 50% N as FYM + Bio-fertilizers resulted in superior growth (Plant height (7.21% and 9.97%), dry matter accumulation (9.21% and 9.11%) and number of tillers (14.21% and 18.85%)), grain yield (15.24% and 19.50%) and evapotranspiration (8.77% and 8.23%) compared to RDF. Based on results, the irrigation regimes IW:CPE ratio 1.60 (receiving 3 and 4 irrigations in 2017and 2018, respectively) and application of 50% RDF (N) + 50% N through FYM + Bio-fertilizers could be followed for enhancing the growth and yield of direct seeded autumn rice under upland conditions of Assam.

INTRODUCTION

In rice-producing states of India like Punjab, Haryana, U.P., Bihar, Terai of Uttaranchal, Orissa, Chhattisgarh and West Bengal, a shift towards DSR in suitable eco-systems has been noticed in recent years (Gupta *et al.*, 2006; Ladha *et al.*, 2009). Transplanting is the most common method of rice cultivation in India but owing to increasing water scarcity, scarce labour coupled with higher wages during the peak periods, a shift towards less demanding alternative methods of rice cultivation aiming at higher water and crop productivity, is imperative. To overcome these problems, aerobic rice systems, where in the crop is established via direct-seeding in non-puddled, non-flooded fields, are among the most promising approaches for saving water and labour (Tabbal *et al.*, 2002 and Kaur, 2004). The most important prerequisites for a successful crop of direct-seeded rice are: (1) good crop establishment, (2) weed management (3) precision water management and (4) nutrient management (Kumar and Ladha, 2011). Apart from the first two aspects, the latter two are i.e; water and nutrient management are of greater considerations for increasing yield of the crop.

Dry sown rice (DSR) system can reduce water application by about 44 percent relative to the conventional transplanted system, (Sharma *et al.,* 2002 and Kaur, 2004) by reducing percolation, seepage and evaporation losses (Bouman *et al.*, 2005). Shekara *et al.* (2011) reported irrigation schedule at IW:CPE of 2.5 recorded higher plant height, dry matter accumulation, productive tillers hill^{-1}, filled spikelet panicle^{-1}, panicle weight, filled grains and grain yield of crop than other (IW:CPE ratios of 2.0, 1.5 and 1.0) irrigation practices. Likewise, in an experiment conducted by Subramanian *et al.* (2008) at Coimbatore, Tamil Nadu, the highest grain yield was recorded with IW: CPE 1.2 than the other treatments viz., IW:CPE 0.8, IW:CPE 1.0. Similarly, Jadhav *et al.* (2003) reported increased grain yield with an increase in irrigation regimes from IW: CPE ratio 0.8 to 1.6. An experiment conducted at AAU, Jorhat revealed that grain and straw yield of direct-seeded rice increased with increasing in irrigation regimes from irrigation at 25% ASMD to maintenance of saturation throughout the cropping season (Gogoi, 1978).

Umashankar *et al.* (2005), reported that the application of enriched FYM 12.5 t ha^{-1} + neem cake blended urea + K in combination with seed soaking of *Azospirillum* produced taller plants, increased number of tillers/m^2, higher leaf area index, maximum dry matter production and yield of grain as compared to other treatments (FYM + NPK, enriched FYM + NPK, FYM + neem cake blended urea + PK and inorganic application of nutrients). Works of Choudhary and Suri (2014) from Himachal Pradesh reported that maximum number of panicles m^{-2} and panicle length (cm) were recorded under the INM practice of $N–P_2O_5–K_2O$ @ 90:45:45 kg ha^{-1} + FYM @ 5 t ha^{-1} compared to its lower doses of NPK + FYM @ 5 t ha^{-1} and control ($N–P_2O_5–K_2O$ @ 30:15:15 kg ha^{-1}).

In Assam as the crop is mostly grown as rainfed one, the poor productivity is mainly due to inadequate rainfall during early crop season coupled with acute weed problems causing high competition for both moisture and nutrients. Application of adequate irrigation (Sharma *et al.,* 2013(a)) and nutrient (Hnamte *et al.,* 2013, Mali and Bodhankar (2009) and Sharma *et al.,* 2013(b)) supply leads to successful growth and yield of direct-seeded rice. Keeping these facts in view, the present study is designed to find out the optimum irrigation requirement and suitable nutrient management practice for direct-seeded autumn rice.

MATERIALS AND METHODS

The climatic condition of Jorhat as a whole is sub-tropical humid having hot summer and cold winter. The normal monsoon rain in this track starts from June and continues up to September with the pre-monsoon shower starting from mid-March. The intensity of rainfall decreases from October reaching the minimum during December/January. In general, the maximum temperature rises to 34-37°C during summer and the minimum comes down to 8-10°C during winter.

The experiment was laid out in a split-plot design with 3 replications. The entire experimental field was divided into as many numbers of main plots as per treatments of four irrigations in each replication and allocated randomly. Each main plot was subdivided into five sub-plots as per five treatments of integrated nutrient management practices which were also allocated randomly. The main plot treatments were I_0- Rain-fed, I_1- IW: CPE =1.20, I_2– IW: CPE =1.40 and I_3 - IW: CPE =1.60. The subplot treatments were N_1- Recommended dose of fertilizers (RDF), N_2 - RDF + FYM @ 5t/ha, N_3 -75% RDF + 25% N through FYM , N_4-50% RDF + 50% N through FYM and N_5- 50% N of RDF + 50% N as FYM + Bio-fertilizer (Consortium of *Azotobacter* and PSB). All the organic manures were applied once as a basal dose and incorporated in the soil 15 days before sowing. Half dose of urea, a full dose of SSP and MOP was applied as basal dose and the remaining half of urea was applied as top-dressing. The seed of DSR under N_5- 50% N of RDF + 50% N as FYM + Bio-fertilizer (Consortium of *Azotobacter* and PSB) treatment were mixed with a slurry of the consortium before sowing. The spacing maintained 10 cm x 20 cm for direct-seeded rice. The observations were made by using standard procedures and the data were analyzed as per the statistical methods are given by Panse and Sukhatme (1995).

The rice variety used in the experiment was *Inglongkiri*. It is a tall variety recommended for direct-seeded, rain-fed upland/ *Jhum* situations of Hill zones of Assam. It was developed at the Regional Agricultural Research Station, Diphu, Assam Agricultural University, and released in 2011. It has the good tillering ability, broad droopy leaves, desired plant height, good early vigor. It is a medium duration variety (110 days) with an average the yield of 2.8 t ha^{-1}. It is resistant to blast and moderately resistant to stem borer, case worm, and leaf folder.

The meteorological data, recorded in the meteorological observatory of the Department of Agricultural Meteorology, Assam Agricultural University, Jorhat - 13 during the period of experimentation.

During the 1st year of investigation of direct-seeded autumn rice received 650.6 mm of rainfall in 41 rainy days with the maximum weekly total rainfall was115.9 mm received in 13th week (26th March to 1st April 2017). The total evaporation during the crop growing period was 295.3 mm and the weekly mean evaporation varied from 2.1 mm to 4.2 mm. Thus, there was exceeded by 355.3 mm of evapotranspiration demand for direct-seeded rice crop during the first year of observation. The weekly mean maximum temperature varied from 25.6°C to 31.7°C and weekly mean minimum temperature ranged between 14.3°C to 24.2°C during direct-seeded rice crop. The weekly average relative humidity during the morning hours varied from 90% to 97% and in the evening hours it ranged between 53% to 82% during the crop period and the mean weekly bright sunshine hours ranged between 1.9 hours/ day (13th week) to 7.4 hours/day (15th week) during direct-seeded rice crop.

During the 2nd year of investigation 456.6 mm rainfall was received in 27 spells with the highest weekly total rainfall was 86.3 mm received in the 21st week (21st May to 27th May 2018). The total evaporation was 334.7 mm during direct-seeded rice and the weekly mean evaporation varied from 1.3 mm to 4 mm. This indicated that similar to that of the first year of the investigation there was exceeded by 147.3 mm of evapotranspirational demand during the period of direct-seeded rice crop. The weekly mean maximum temperature varied from 22.5°C to 33.2°C and the weekly mean minimum temperature ranged between 11.6°C to 24.6°C. The weekly average relative humidity ranged from 85% to 99% during the morning hours and 55% to 79% during evening hours and the mean bright sunshine hours varied from 1.5 hours/ day to 7.3 hours/day.

Irrigation

Each subplot was provided with a uniform depth of 5 cm irrigation for direct-seeded rice according to different IW: CPE ratios (Parihar *et al.*, 1974). The details of dates of irrigation for each treatment along with the number of irrigations and the total quantity of water applied are given in Table 2.

The amount of irrigation water was measured as follows:

$q = a \times d$

Where,

q = quantity of water needed for each irrigation (m^3)

a = area to be irrigated (plot size-12 m^2)

d = 5cm

So, irrigation water applied in each irrigation to-

$q = 12\ m^2 \times 0.05\ m$

$= 0.60\ m^3\ plot^{-1}$

$= 600$ litre $plot^{-1}$

Average discharge rate of the pump = 3.5 l/sec

Therefore, time required to irrigate the individual plot,

$$T = \frac{\text{Amount of water}}{\text{Discharge rate of pump}}$$

$$= \frac{600}{3.5}$$

= 171.43 sec

= 2 min 51 sec

The field was irrigated as per the required time (approximately 3 min) to supply required 600 liters of water/plot in the plots with irrigation treatment.

Soil moisture studies

Evapotranspiration by crop

The evapotranspiration by direct seeded rice crop was computed from the soil moisture data by using the following formula (Monteith, 1965):

$$ET = \sum_{i=1}^{n}(E_0 \times K_c \times K_p)\sum_{i=1}^{n}\frac{(M_{1i} - M_{2i})}{100} \times ASG_i \times D_i + ER + GWC$$

Where,

ET = Evapotranspiration (cm)

E_0 = Pan evaporation value (cm) from USWB class A pan evaporimeter from the day of irrigation to the day when sampling in wet soil is possible

N = Time interval (days)

M_{1i} = Percent of soil moisture of the i^{th} layer on the date of sampling after irrigation

M_{2i} = Percent soil moisture of the i^{th} layer on the date of sampling before irrigation

ASG_i = Apparent Specific Gravity of i^{th} soil layer

D_i = Depth (cm) of the i^{th} layer of the soil

ER = Effective Rainfall during the period under consideration

N = Number of soil layers

K_c = Crop coefficient

K_p = Pan coefficient

GWC = Groundwater contribution (Determined with the help of the procedure described by Anat *et al.* (1965)

Water use efficiency

Water use efficiency (WUE) of the crop for different treatments was calculated as follows (Briggs and Shantz, 1913):

$$\text{Crop WUE (kg/ha-cm)} = \frac{\text{Weight of seed (kg/ ha)}}{\text{ET of crop (cm)}}$$

RESULTS AND DISCUSSION

Effect of irrigation

The growth characteristics, like plant height, dry matter accumulation and number of tillers per square meter recorded at different growth stages of rice *viz.,* 25 DAS, 50 DAS, 75 DAS and at harvest revealed that different irrigation practices significantly influenced the growth parameters (Table 5 to Table 8) in all the stages of observations except 25 DAS in both the years. The growth parameters at 50, 75 DAS and harvest significantly increased due to irrigations applied at IW: CPE ratio 1.60 over that of irrigations at IW: CPE ratio 1.20 and rainfed. The total grains/panicle, filled grains/ panicle, 1000-grain weight, grain yield, straw yield and harvest index were observed in both the year. The yield parameters (Table 5 to Table 12) were significantly increased due to irrigations applied at IW: CPE ratio 1.60 over that of irrigations at IW: CPE ratio 1.20 and rainfed. On the other hand, during both the year the differences in growth parameters at different stages and yield attributes due to irrigation at IW: CPE ratio 1.60 and IW: CPE ratio 1.40 was similar with the same number of irrigations but both were proved significantly superior to IW: CPE ratio 1.20 and rainfed. The beneficial effect of irrigation schedule may be attributed to several physicochemical changes in plants *viz.,* increase inbound water and increase in the intensity of respiration and photosynthesis, more intense transpiration and lower water deficits (De Datta, 1975). The higher values in growth parameters due to irrigation at IW: CPE ratio 1.60 may be attributed to higher moisture availability resulting from optimum soil moisture level with proper root proliferation (Matsumato *et al.*, 2014 and Shekara *et al.*, 2011) under the treatments and thereby facilitated better water and nutrient uptake by the plant (Balamani *et al.*, 2012, Boruah, 2018, Jedidi *et al.*, 2004, Pal *et al.*, 2013, Balasubramanian and Krishnarajan, 2001, Parihar, 2004 and Singh *et al.*, 1997). The higher yield due to the irrigation at IW: CPE ratio 1.60 was at par with that of irrigation at IW: CPE ratio 1.40. This may be due sufficient amount of rainfall received during later stages of the crop and thereby irrigations became ineffective. Significantly the lowest yield was obtained under rainfed and IW: CPE ratio 1.20 in both the years compared to irrigation at IW: CPE ratio 1.60 and IW: CPE ratio 1.40. This may be due to less plant population, the number of panicles, higher unfilled grains per panicle resulting from the inadequate moisture availability at the initial growth stages of the crop under rainfed. Favorable influence of irrigation on grain yield of direct-seeded rice over rainfed crops has been reported by (Luikham *et al.*, 2014 and Parihar, 2004). The better response of higher (frequent) irrigation regimes on growth parameters and yield attributes might be due to sufficient availability of moisture which ultimately reflected in producing the higher grain and straw yield and harvest index of the crop under these irrigation regimes (Shekhara *et al.*, 2010). Further, it can be explained from the fact that increased irrigation frequency might be attributed to better vegetative crop growth and development which ultimately increased the translocation of assimilates from source to sink thus, resulting in increased grain (Subramanian *et al.*, 2008) and straw yield under the treatments. The higher irrigation requirements under IW: CPE ratio 1.60 (12.51 and 13.80 cm in 2017 and 2018, respectively) and IW: CPE ratio 1.40 (9.60 and 13.70 cm in 2017 and 2018, respectively) might have resulted in higher evapotranspiration and total water use by the crop over their lower irrigation regime IW: CPE ratio 1.20 and rainfed. The higher available water in the soil profile that facilitated more evapotranspiration as compared to lower irrigation regime and rainfed may further be attributed to increasing the water use by the crop (Gogoi, 1978, Jadhav *et al.*, 2003, Jadhav and Dahiphale, 2005, Ramamoorthy *et al.*, 1996 and Sorour *et al.*, 1998). The evapotranspiration (Table 12) by the crop is the prime factor that determines the crop water use efficiency, respectively and has an inverse relationship. However, the higher grain yield of rice realized under the higher irrigation regime IW:CPE ratio1.60 led to producing considerably higher crop water use efficiency. Similar results of higher crop water use

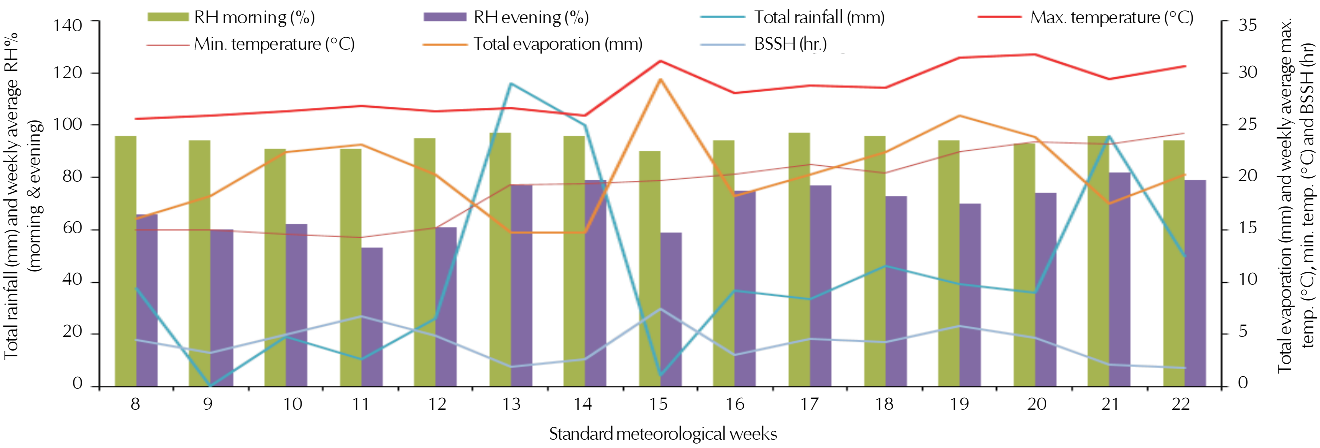

Figure 1: Weekly meteorological data during crop growing period of direct seeded autumn rice (Feb, 2017 - June, 2017)

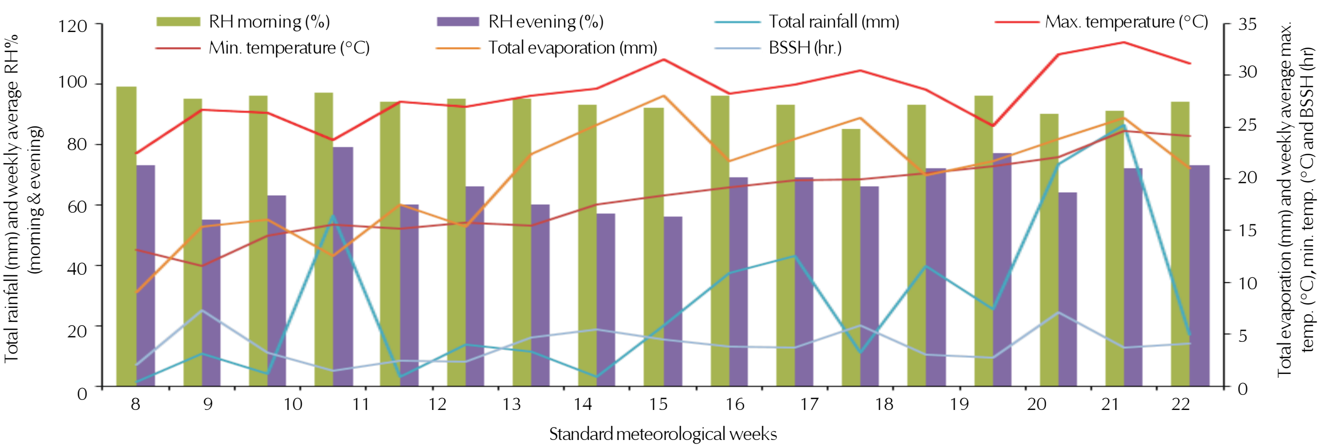

Figure 2: Weekly meteorological data during crop growing period of direct seeded autumn rice (Feb, 2018 - June, 2018)

efficiency due to increased grain yield of rice with intensive irrigation regime have also been reported by Bali and Uppal (1999), Horie *et al.* (2005) and O'Toole (1982).

Effect of nutrient management

Different nutrient management practices significantly influenced the growth parameters (Table 5 to Table 8) recorded at all the growth stages of rice except 25 DAS during both the year. The growth parameters recorded at 50, 75 DAS and harvest due to the application of 50% RDF(N) + 50% N through FYM + Bio-fertilizers and RDFN + FYM @ 5t/ha were at par in their effect and both produced significantly higher values in growth parameters over-application of RDF alone during both the year. The nutrient management practice 50% RDF (N) + 50% N through FYM + Bio-fertilizers showed superior results of yield attributes and yield (Table 9 to Table 11) in both the year, followed by RDF + FYM @ 5t/ha. The higher growth under biofertilizer inoculation due to more availability of nutrients at various growth stages resulting in greater nutrients absorption and better availability of moisture and nutrients due to incorporation of FYM. The superior yield may be resulted from the higher growth parameters like plant height, dry matter accumulation, crop growth rate and number of effective tillers of the crop (Tripathi *et al.*, 2010). Reports also indicated that application of chemical fertilizers in combination with organic manures and bio-fertilizers gave adequate amount of nitrogen, phosphorus and potassium as per crop's requirement (Haq *et al.*,2005) and led to increase the grain and straw yield of rice (Kumar, 2016). These findings are in close conformity with those Arya (2015), Das and Singh, (2014), Patil and Bhilare, (2000), Priyanka *et al.* (2013), Rathore *et al.*, (2014), Sharma, (1983), Solunke *et al.* (2006) and Tomar *et al.* (2018). The higher values of evapotranspiration (Table 12) by the crop observed with 50% RDF (N) + 50% N through FYM + Bio-fertilizers followed by RDF + FYM @ 5t/ha might be due to greater extraction of soil moisture as a result of higher crop growth, yield attributes and grain yield of rice. The results were in good conformity with that of the findings of Chaoudhary *et al.* (2006), Senthivelu and Prabha, 2007 and Tomar *et al.*, 2018. Reports (Das *et al.*, 2014, Jeyalal *et al.*, 1999, Rajkhowa, 2003 and Vasanthi and Kumaraswamy (1999)) also indicated that application of organic sources of nutrients and bio-fertilizers improved the soil physical properties and moisture retention that helped to increase the crop growth, yield attributes and yield which may directly enhance the crop water use efficiency.

Table 1: Initial physicochemical properties of the soil

Soil property	Value	Method employed
A. Physical properties		
Soil texture		
i) Sand (%)	65.01	International Pipette method (Piper, 1966)
ii) Silt (%)	19.09	
iii) Clay (%)	15.43	
Textural class	Sandy Loam	
Bulk density (g/cc)	1.38	Core sampler method (Piper, 1966)
Field capacity (%)	26.60	Pressure plate apparatus (Richards and Fireman, 1943)
Permanent wilting point (%)	10.25	Pressure plate apparatus (Richards and Fireman, 1943)
Water holding capacity (%)	41.20	Ken Rackzowski box (Piper,1966)
B. Chemical properties		
Soil reaction (pH)	5.60 (Acidic)	Glass electrode method(Jackson, 1973)
Organic carbon (%)	0.65 (Medium)	Wet digestion method (Walkey and Black, 1934)
Available N (kg ha^{-1})	226.63 (Low)	Alkaline potassium permanganate method (Subbiah and Asija, 1956)
Available P_2O_5(kg ha^{-1})	21.18 (Low)	Bray-I Method (Jackson, 1973)
Available K_2O (kg ha^{-1})	127.71 (Low)	Neutral normal ammonium acetate method (Jackson, 1973)

Table 2: Number and dates of irrigation in various treatments

Treatments	Date of application	No. of irrigations	The depth of each irrigation (cm)	The total depth of irrigation water (cm)
Direct seeded rice, 2017				
I_0				
I_1	10.3.2017 and 18.4.2017	2	4.02 and 3.91	7.93
I_2	08.3.2017, 20.3.2017and 15.4.2017	3	4.02, 1.22 and 4.36	9.60
I_3	06.3.2017, 17.3.2017and 14.4.2017	3	5.00, 3.15 and 4.36	12.51
Direct seeded rice, 2018				
I_0				
I_1	1.3.2018, 22.3.2018 and 3.4.2018	3	2.33, 3.36 and 3.69	9.38
I_2	25.2.2018, 20.3.2018, 30.3.2018 and 15.4.2018	4	3.66, 3.36, 3.69 and 2.99	13.70
I_3	22.2.2018, 17.3.2018, 28.3.2018 and 6.4.2018	4	3.93, 3.52, 1.47 and 4.87	13.80

Table 3: Moisture content and NPK content of FYM

Properties of FYM	2016-17		2017-18	
	Indian mustard	Direct seeded rice	Indian mustard	Direct seeded rice
Moisture content	37.34%	38.30%	35.12%	36.72%
Nitrogen content	0.55%	0.54%	0.55%	0.56%
Phosphorus content	0.23%	0.26%	0.25%	0.26%
Potassium content	0.48%	0.49%	0.50%	0.49%

Table 4: Percent substitution of N in RDF by FYM as per INM treatmen

Sources	Treatments	*RDFN (%)	N- kg/ha	N- kg/plot	Urea/FYM required (kg/ha)	(kg/plot)
Direct seeded rice (2017 and 2018)						
Urea (2017 and2018)	N_1	100	40	0.048	87	0.10
	N_2	100	40	0.048	87	0.10
	N_3	75	30	0.036	65	0.08
	N_4	50	20	0.024	43.5	0.05
	N_5	50	20	0.024	43.5	0.05
FYM(2017)	N_1	-	-	-	-	-
	N_2	5 t/ha	27	0.032	8100	9.80
	N_3	25	10	0.012	3000	3.60
	N_4	50	20	0.024	6000	7.20
	N_5	50	20	0.024	6000	7.20
FYM(2018)	N_1	-	-	-	-	-
	N_2	5 t/ha	28	0.033	7900	9.50
	N_3	25	10	0.012	2820	3.40
	N_4	50	20	0.024	5640	6.80
	N_5	50	20	0.024	5640	6.80

*Recommended dose of fertilizer Nitrogen applied as per treatment

Table 5: Effect of irrigation and nutrient management on plant height of direct seeded autumn rice

Treatments	Plant height (cm)							
	2017				2018			
Irrigation (I)	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
Rainfed	31.94	57.94	75.67	93.14	29.34	59.70	74.42	96.23
IW:CPE = 1.20	33.61	63.28	82.08	104.21	28.97	64.63	83.92	105.95
IW:CPE = 1.40	34.21	70.14	93.01	113.34	33.90	71.97	97.34	113.45
IW:CPE = 1.60	35.00	70.47	102.20	117.67	33.36	74.11	106.91	120.96
S.Ed±	1.03	2.10	1.89	2.99	2.03	1.86	2.65	1.75
CD: (P=0.05)	N.S	5.15	4.63	7.31	N.S	4.56	6.50	4.29
Nutrient Management (N)								
Recommended dose of fertilizer (RDF)	33.47	62.22	83.72	104.05	32.34	63.65	85.65	104.66
RDF + FYM @ 5t/ha	34.82	67.07	91.23	109.98	32.08	68.82	93.33	112.69
75% RDF(N) + 25%N through FYM	32.72	63.63	86.05	103.88	30.95	66.02	88.14	106.55
50% RDF(N) + 50% N through FYM	32.70	64.78	87.70	105.70	31.06	67.24	89.79	106.18
50% RDF(N) + 50% N through FYM + Bio-fertilizers	34.75	69.59	92.50	111.84	30.55	72.30	96.34	115.65
S.Ed±	0.92	2.20	2.21	2.40	1.23	2.21	1.89	2.23
CD: (P=0.05)	N.S	4.48	4.51	4.90	N.S	4.503	3.85	4.55
Interaction (I × N)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 6: Effect of irrigation and nutrient management on dry matter accumulation of direct seeded autumn rice

Treatments	Dry matter accumulation (g/plant)							
	2017				2018			
Irrigation (I)	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
Rainfed	1.64	4.39	7.98	11.00	1.68	4.45	7.87	11.10
IW:CPE = 1.20	1.67	5.49	8.86	12.12	1.70	6.04	8.83	12.60
IW:CPE = 1.40	1.68	6.50	9.73	13.00	1.74	6.58	9.84	13.01
IW:CPE = 1.60	1.71	7.02	9.89	13.88	1.78	7.14	10.03	14.05
S.Ed±	0.02	0.11	0.13	0.09	0.04	0.09	0.19	0.12
CD: (P=0.05)	N.S	0.27	0.33	0.22	N.S	0.22	0.48	0.31
Nutrient Management (N)								
Recommended dose of fertilizer (RDF)	1.62	5.53	8.73	11.91	1.66	5.71	8.71	12.15
RDF + FYM @ 5t/ha	1.67	6.04	9.44	12.85	1.74	6.24	9.48	12.99
75% RDF(N) + 25%N through FYM	1.67	5.68	8.74	12.33	1.73	5.88	8.77	12.46
50% RDF(N) + 50% N through FYM	1.70	5.84	8.91	12.30	1.73	6.05	8.91	12.53
50% RDF(N) + 50% N through FYM + Bio-fertilizers	1.71	6.18	9.76	13.06	1.70	6.38	9.84	13.31
S.Ed±	0.03	0.10	0.15	0.16	0.03	0.13	0.14	0.19
CD: (P=0.05)	N.S	0.22	0.31	0.33	N.S	0.28	0.30	0.40
Interaction (I × N)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 7: Effect of irrigation and nutrient management on crop growth rate of direct seeded autumn rice

Treatments	Crop growth rate ($g/m^2/day$)							
	2017				2018			
Irrigation (I)	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
Rainfed	3.28	5.50	5.74	4.41	3.37	5.58	6.80	4.61
IW:CPE = 1.20	3.33	7.65	6.47	4.66	3.41	8.82	5.44	5.39
IW:CPE = 1.40	3.36	9.64	6.73	4.67	3.48	9.63	6.56	4.53
IW:CPE = 1.60	3.42	10.63	7.17	5.70	3.56	10.62	5.87	5.73
S.Ed±	0.04	0.22	0.20	0.18	0.08	0.75	0.75	0.19
CD: (P=0.05)	N.S	0.55	0.50	0.46	N.S	1.85	1.83	0.46
Nutrient Management (N)								
Recommended dose of fertilizer (RDF)	3.23	7.82	6.42	4.65	3.33	8.15	5.94	4.92
RDF + FYM @ 5t/ha	3.35	8.72	6.81	4.87	3.49	9.00	6.48	5.01
75% RDF(N) + 25%N through FYM	3.34	8.01	6.12	5.13	3.47	8.33	5.75	5.27
50% RDF(N) + 50% N through FYM	3.40	8.27	6.13	4.92	3.46	8.6	5.72	5.17
50% RDF(N) + 50% N through FYM + Bio-fertilizers	3.42	8.94	7.16	4.71	3.53	9.22	6.93	4.95
S.Ed±	0.07	0.23	0.32	0.25	0.07	0.23	0.35	0.31
CD: (P=0.05)	N.S	0.48	0.65	N.S	N.S	0.483	0.72	N.S
Interaction (I × N)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 8: Effect of irrigation and nutrient management on number of tillers of direct seeded autumn rice

Treatments	Number of tillers/m²							
	2017				2018			
Irrigation (I)	25 DAS	50 DAS	75 DAS	At harvest	25 DAS	50 DAS	75 DAS	At harvest
Rainfed	114.61	161.07	211.47	201.78	111.47	161.33	213.31	204.07
IW:CPE = 1.20	115.27	173.07	240.07	230.55	112.21	169.70	242.82	234.08
IW:CPE = 1.40	117.07	174.67	269.81	261.90	113.41	172.82	273.38	266.83
IW:CPE = 1.60	118.87	186.74	329.60	320.41	116.74	190.90	336.98	329.06
S.Ed±	1.74	5.72	2.12	3.14	2.10	7.62	4.66	5.42
CD: (P=0.05)	N.S	14.00	5.19	7.69	N.S	18.64	11.41	13.27
Nutrient Management (N)								
Recommended dose of fertilizer (RDF)	113.78	169.12	243.53	235.90	111.12	167.36	240.40	233.43
RDF + FYM @ 5t/ha	118.82	177.82	274.90	264.58	114.23	177.22	282.23	272.48
75% RDF(N) + 25%N through FYM	114.78	170.70	256.45	247.45	112.03	172.93	254.86	249.10
50% RDF(N) + 50% N through FYM	115.91	172.08	256.41	248.35	113.66	174.80	265.63	255.50
50% RDF(N) + 50% N through FYM + Bio-fertilizers	118.98	179.73	282.40	272.01	116.23	176.13	289.99	82.03
S.Ed±	2.36	2.97	5.62	5.00	2.69	2.91	4.83	5.40
CD: (P=0.05)	N.S	6.05	11.46	10.19	N.S	5.93	9.84	11.01
Interaction (I × N)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 9: Effect of irrigation and nutrient management on yield attributes of direct seeded autumn rice

Treatments	Number of panicles/m²		Weight of panicles (g/m²)		Length of panicle (cm)	
	2017	2018	2017	2018	2017	2018
Irrigation (I)						
Rainfed	157.93	160.00	296.47	273.80	17.18	17.42
IW:CPE = 1.20	168.90	172.52	351.80	371.93	17.81	17.64
IW:CPE = 1.40	197.59	197.73	478.13	517.47	17.86	17.72
IW:CPE = 1.60	201.58	205.20	498.80	531.46	17.95	17.90
S.Ed±	4.02	3.78	13.14	24.54	0.36	0.19
CD: (P=0.05)	9.85	9.26	32.16	60.05	N.S	N.S
Nutrient Management (N)						
Recommended dose of fertilizer (RDF)	171.01	172.93	341.17	360.67	17.14	17.19
RDF + FYM @ 5t/ha	189.86	192.68	444.17	446.10	17.92	17.80
75% RDF(N) + 25%N through FYM	177.13	179.19	392.17	417.25	17.75	17.73
50% RDF(N) + 50% N through FYM	176.47	179.39	402.33	433.08	17.71	17.67
50% RDF(N) + 50% N through FYM + Bio-fertilizers	193.03	195.14	451.66	461.16	17.97	17.96
S.Ed±	3.98	6.54	15.83	17.02	0.31	0.25
CD: (P=0.05)	8.10	13.32	32.26	34.67	N.S	N.S
Interaction (I x N)	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 10: Effect of irrigation and nutrient management on number of grains per panicle and 1000 – grain weight of direct seeded autumn rice

Treatments	Grains per panicle						1000 - grain weight (g)	
	Filled grains		Unfilled grains		Total grains			
	2017	2018	2017	2018	2017	2018	2017	2018
Irrigation (I)								
Rainfed	102.67	99.33	15.11	15.13	117.80	114.47	21.29	21.41
IW:CPE = 1.20	110.17	116.84	14.02	14.03	124.20	130.87	21.35	21.48
IW:CPE = 1.40	115.07	120.74	13.03	13.36	128.10	134.10	21.43	21.57
IW:CPE = 1.60	120.41	125.87	11.75	12.96	132.16	138.83	21.59	21.65
S.Ed±	2.73	3.12	0.64	0.53	2.79	3.16	0.23	0.08
CD: (P=0.05)	6.69	7.63	1.58	1.30	6.84	7.74	N.S	N.S
Nutrient Management (N)								
Recommended dose of fertilizer (RDF)	98.96	103.08	15.43	15.48	114.38	118.55	21.12	21.26
RDF + FYM @ 5t/ha	117.54	121.58	12.83	12.96	130.37	134.53	21.63	21.78
75% RDF(N) + 25%N through FYM	106.79	110.40	13.96	14.52	120.75	124.92	21.00	21.16
50% RDF(N) + 50% N through FYM	111.23	115.30	13.76	13.86	125.00	129.16	21.52	21.58
50% RDF(N) + 50% N through FYM + Bio-fertilizers		125.88	128.13	11.45	12.53	137.33	140.66	21.83
21.86								
S.Ed±	3.47	4.28	0.61	0.73	3.43	3.60	0.35	0.56
CD: (P=0.05)	7.08	8.73	1.24	1.49	6.98	7.33	N.S	N.S
Interaction (I x N)	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 11: Effect of irrigation and nutrient management on yield of direct seeded autumn rice

Treatments	Grain yield (q/ha)			Straw yield (q/ha)		Harvest index (%)	
	2017	2018	Pooled	2017	2018	2017	2018
Irrigation (I)							
Rainfed	18.66	18.20	18.43	30.98	29.57	37.58	38.09
IW:CPE = 1.20	20.32	21.29	20.81	31.59	33.32	39.14	39.02
IW:CPE = 1.40	25.34	25.65	25.49	35.11	36.77	41.95	41.10
IW:CPE = 1.60	26.01	26.25	26.13	35.59	37.33	42.28	41.34
S.Ed±	0.43	0.52	0.40	1.18	0.69	0.99	0.53
CD: (P=0.05)	1.05	1.27	1.28	2.89	1.68	2.43	1.29
Nutrient Management (N)							
Recommended dose of fertilizer (RDF)	20.73	21.03	20.88	31.49	32.14	39.55	39.42
RDF + FYM @ 5t/ha	23.73	24.09	23.87	35.16	36.41	40.09	39.58
75% RDF(N) + 25%N through FYM	21.73	21.89	21.85	31.78	32.44	40.54	40.26
50% RDF(N) + 50% N through FYM	22.56	22.86	22.72	32.20	33.12	41.02	40.68
50% RDF(N) + 50% N through FYM + Bio-fertilizers	24.15	24.36	24.26	35.95	37.12	39.98	39.50
S.Ed±	0.68	0.71	0.04	0.99	0.99	0.97	1.00
CD: (P=0.05)	1.38	1.44	0.11	2.03	2.02	N.S	N.S
Interaction (I × N)	N.S	N.S	N.S	N.S	N.S	N.S	N.S

N.S: Non-significant

Table 12: Effect of irrigation and nutrient management on water use and water use efficiency of direct seeded autumn rice

Treatments	Evapotranspiration (cm)		Crop water use efficiency (kg/ha-cm)	
	2017	2018	2017	2018
Irrigation (I)				
Rainfed	29.14	27.50	64.01	66.49
IW:CPE = 1.20	32.58	35.60	62.36	59.77
IW:CPE = 1.40	32.65	36.40	77.53	70.41
IW:CPE = 1.60	33.04	37.14	78.66	70.63
Nutrient Management (N)				
Recommended dose of fertilizer (RDF)	30.09	32.37	68.75	65.00
RDF + FYM @ 5t/ha	32.74	35.12	72.20	68.15
75% RDF(N) + 25%N through FYM	31.17	33.56	69.53	65.52
50% RDF(N) + 50% N through FYM	32.40	34.42	69.42	66.30
50% RDF(N) + 50% N through FYM + Bio-fertilizers	32.85	35.15	73.29	69.15

CONCLUSIONS

Direct seeded rice is mostly cultivated as a rainfed crop in Assam conditions and there is a need for irrigation and nutrient management practices for better growth and yield. From the present experiment, It was concluded that, the application of irrigation regime IW: CPE ratio 1.60 showed superior results on growth, yield and consumptive use of water of rice followed by IW: CPE ratio 1.40. The nutrient management practice 50% RDF (N) + 50% N through FYM + Bio-fertilizers and RDF + FYM @ 5t/ha resulted in superior values of growth and yield of rice over rest of the nutrient practices with high availability of nutrients with higher consumptive use by crop.

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