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**Vasuki A**

PG Scholar, Agricultural College and Research Institute, Killikulam, Vallanadu Post Thoothukudi District, Tamil Nadu, India

**M Joseph**

Associate Professor, Department of Agronomy, Agricultural College and Research Institute, Killikulam, Vallanadu Post Thoothukudi District, Tamil Nadu, India

**D Rajakumar**

Assistant Professor, Department of Agronomy, Agricultural College and Research Institute, Killikulam, Vallanadu Post Thoothukudi District, Tamil Nadu, India

**B Jeberlin Prabina**

Associate Professor, Agriculture Micro, Department of Soil Science and Agricultural Chemistry, Agricultural College and Research Institute, Killikulam, Vallanadu Post Thoothukudi District, Tamil Nadu, India

**Corresponding Author:****Vasuki A**

PG Scholar, Agricultural College and Research Institute, Killikulam, Vallanadu Post Thoothukudi District, Tamil Nadu, India

## Influence of nutrient levels and irrigation regimes on yield attributes, yield and WUE of transplanted rice under Tamirabarani command area

Vasuki A, M Joseph, D Rajakumar and B Jeberlin Prabina

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**Abstract**

Field experiment was conducted at Agricultural college and research institute, Killikulam during early pishanam (2019 to 2020) to find out the optimum level of nitrogen and irrigation regimes to enhance the yield and WUE of transplanted rice. The experiment was laid out in strip plot design and replicated thrice. The vertical strips consists of 3 irrigation regimes namely irrigation at 10 cm depletion of field water tube (FWT) from 10 DAT to 10 days prior to harvest (A<sub>1</sub>), irrigation at 15 cm depletion of field water tube (FWT) up to maximum tillering stage (30-35 DAT) and thereafter 10 cm depletion of field water tube (FWT) up to 10 days prior to harvest (A<sub>2</sub>) and continuous flooding (A<sub>3</sub>) and the horizontal strip consists of nutrient management practices such as 100% RDF alone (B<sub>1</sub>), 100% RDF along with recommended dose of GLM (B<sub>2</sub>), 125 % RDF (100% N through inorganic + 25% N through GLM) (B<sub>3</sub>), 150% RDF (100% N thorough inorganic + 50% N through GLM) (B<sub>4</sub>) and absolute control (B<sub>5</sub>). Green manure glyricidia was taken as GLM. Observations on yield attributes like productive tillers, number of grains and filled grains panicle<sup>-1</sup>, panicle length and 1000 grain weight, and also grain and straw yield were recorded. Total water consumed and water use efficiency also worked out for different treatment combinations. The obtained results showed that continuous flooding with application of 150% RDF (100% N through inorganic and 50% N through GLM) (A<sub>3</sub>B<sub>4</sub>) recorded highest yield attributes like panicle length, number of grains and filled grains per panicle, number of productive tillers and 1000 grain weight, grain yield of about 8571 kg ha<sup>-1</sup> and straw yield of about 9347 kg ha<sup>-1</sup>. However WUE was higher in irrigation at 15 cm depletion of field water tube along with 150% (100% N through inorganic and 50% N through GLM) (A<sub>2</sub>B<sub>4</sub>) 9.12 kg ha-mm<sup>-1</sup>.

**Keywords:** Rice, irrigation regimes with field water tube, nutrient levels, yield and WUE

**Introduction**

Rice is an important cereal crop grown exclusively in tropical and subtropical regions (Kumar *et al.*, 2014)<sup>[9]</sup>. It is the staple food for half of the world's population. It accounts for the supply of calories of about 20% and 31% of world and Indian population (Singh and Chakraborti, 2019)<sup>[19]</sup>. Rice production accounts for 43% among total food grain production in India. Even though it's grown in most of the countries it's production is constrained by various factors such as declining of water availability, climatic variations and increase in input cost (Ullah and Datta 2018)<sup>[21]</sup>. In India, rice occupies an area of 43.78 million hectares with a production of 112.76 million tones and with an average productivity of 2.58 t ha<sup>-1</sup>. In Tamil Nadu, total area under rice cultivation is about 1.83 million hectares, with a production of about 4.03 million tones and with a productivity of 3630 kg ha<sup>-1</sup> during 2017-18 (GOI, 2017-2018). A major concern in cultivation and production of rice is declining in availability of water. Conventional method of irrigation results in higher surface runoff and percolation accounting for about 50% to 80% of total water input. There is a decreasing trend in availability of water from 78% to 71% by 2025 and 64.6% by 2050. Several water saving technologies has been introduced for cultivation of rice and the most prominent one is safe alternate wetting and drying irrigation method. This method reduces the water usage and also increases WUE (Li and Barker, 2004). Practicing of Safe AWD saves water use from 15% to 30% without any yield reduction. Without any experiencing water stress, re-irrigation is given when water level depletes from 10 15 cm and it is the most prominent method adopted in South and Southeast Asia (Lampayan *et al.*, 2009)<sup>[10]</sup>.

Organic manures provide regulated supply of necessary nutrients for a longer period in a readily available form. But the fact is organic manure alone cannot meet the nutrient need of fertilizer and hence organic manure can be integrated with inorganics to supply the necessary nutrient (Fageria and Baligar, 1997) [3]. Nitrogen is an essential and effective element necessary for the growth of the crop and for obtaining of yield (Singh *et al.*, 2005) [20].

Hence an ideal irrigation and nutrient management practices is necessary to improve the productivity of rice and to overcome the constraints in rice cultivation and production. Hence this study was done to find out the effect of irrigation regimes and nutrient levels on growth and yield of transplanted rice.

### Materials and methods

The field experiment was conducted at Agricultural college and Research institute, Killikulam, Tamil Nadu during early pishanam season (2019 – 2020). The soil was sandy clay loam in texture with pH of 7.3, EC of 0.12 dsm<sup>-1</sup> and organic carbon content of 5.5 g kg<sup>-1</sup>. The soil was low in available nitrogen (154 kg ha<sup>-1</sup>), high in available phosphorus (24 kg ha<sup>-1</sup>) and medium in available potassium (243 kg ha<sup>-1</sup>). The experiment was laid out in strip plot designs and replicated thrice. The treatment consists of three irrigation regimes in vertical strip and five nutrient levels in horizontal strips *viz.*, Irrigation at 10 cm depletion of field water tube (FWT) from 10 DAT to 10 days prior to harvest (A<sub>1</sub>). Irrigation at 15 cm depletion of field water tube (FWT) up to maximum tillering stage (30-35 DAT) and thereafter 10 cm depletion of field water tube (FWT) up to 10 days prior to harvest (A<sub>2</sub>) and continuous flooding (A<sub>3</sub>) in the vertical strips. 100% RDF alone (B<sub>1</sub>), 100% RDF along with recommended dose of GLM (B<sub>2</sub>), 125 % RDF (100% N thorough inorganic + 25% N thorough GLM) (B<sub>3</sub>), 150% RDF (100% N thorough inorganic + 50% N thorough GLM) (B<sub>4</sub>) and absolute control (B<sub>5</sub>) in horizontal strips. Rice variety ASD 16 was chosen for this study. All other agronomic practices like weed control, plant protection measures and harvesting operation were made similar for all treatments. Various observations such as yield and yield attributes of rice, total water consumption and WUE were recorded and worked out.

### Results and Discussion

#### Effect of treatments on yield attributes

Irrigation practices has significant effect on yield attributes. Yield attributes like panicle length (22.12 cm), number of grains per panicle (177) and filled grains per panicle (164), number of productive tillers (299 m<sup>-2</sup>) and 1000 grain weight (22.98 g) was higher in continuous flooding (A<sub>3</sub>) (Table 1 and 2). This might be due to the adequate availability of moisture without any cracks and unrestricted water availability (Kumar *et al.*, 2013 and Ranbir *et al.*, 2009) [9]. However it was similar with irrigation at 10 cm depletion of field water tube (A<sub>1</sub>) recording panicle length (21.22 cm), number of grains per panicle (171), filled grains (160) per panicle, number of productive tillers (291 m<sup>-2</sup>) and 1000 grain weight (22.56 g).

Among nutrient management practices, yield attributes such as panicle length (23.97 cm), number of grains per panicle (200) and filled grains (192) per panicle, number of productive tillers (319 m<sup>-2</sup>), 1000 grain weight (23.87 g) was high in 150% RDF (100% N through inorganic and 50% N through GLM) (B<sub>4</sub>) (Table 2 and 3). It was statistically similar with 125% RDF (100% N through inorganic and 25% N through GLM) (B<sub>3</sub>) recording panicle length (22.73 cm),

number of grains per panicle (188) and filled grains (177) per panicle, number of productive tillers (310 m<sup>-2</sup>), 1000 grain weight (23.50 g). The panicle length was increased by the enhanced nutrient uptake which increased the sink size. Filled grains per panicle was higher due to better fertilization, which resulted in enhanced the growth of roots and shoots and increased nutrient uptake, production of photosynthates and their translocation to sink (Verma and Ali, 2017) [22]. Lowest yield attributes was recorded in absolute control (B<sub>5</sub>) panicle length (17.23 cm), number of grains per panicle (114) and filled grains (102) per panicle, number of productive tillers (196 m<sup>-2</sup>), 1000 grain weight (20.17 g).

Different irrigation and nutrient management practices had substantial interaction effect on yield attributes such as panicle length (25.2 cm), number of grains per panicle (206) and filled grains (198) per panicle, number of productive tillers (337 m<sup>-2</sup>), 1000 grain weight (24.4 g) was higher in continuous flooding with 150% RDF (100% N through inorganic and 50% N through GLM) (A<sub>3</sub>B<sub>4</sub>). (Table 1 and 2).

#### Effect of treatments on yield

Both grain yield (6757.8 kg ha<sup>-1</sup>) and straw yield (7530.6 kg ha<sup>-1</sup>) was increased in continuous flooding (A<sub>3</sub>) (Table 3) due to the production of superior yield attributes (Kumar *et al.*, 2013) [9]. It was followed by irrigation at 10 cm depletion of field water tube (A<sub>1</sub>) recording grain yield 6195.2 kg ha<sup>-1</sup> and straw yield of about 6932.8 kg ha<sup>-1</sup>. This was in accordance with Sathish *et al.*, (2017a) [17] and Kumar *et al.*, (2006) [7]. Lowest grain (5522.4 kg ha<sup>-1</sup>) and straw yield (6258.6 kg ha<sup>-1</sup>) was obtained in irrigation at 15 cm depletion of field water tube (A<sub>2</sub>) due to water scarcity during vegetative and reproductive growth period (Kumar *et al.*, 2013) [9].

Application of 150% RDF (100% N through inorganic and 50% N through GLM) (B<sub>4</sub>) recorded higher grain (7979.3 kg ha<sup>-1</sup>) and straw yield (8833.7 kg ha<sup>-1</sup>) (Table 3) due to high accounting of yield attributes under higher availability of nutrients (Kumar *et al.*, 2013) [9] and it was followed by application of 125% RDF (100% N through inorganic and 25% N through GLM) (B<sub>3</sub>) accounting grain and straw yield of about 7418.3 and 8291.3 kg ha<sup>-1</sup>. Similar observations was obtained by Pal *et al.*, (2005) [13]. Lowest grain yield (3653.7 kg ha<sup>-1</sup>) and straw yield (4187.7 kg ha<sup>-1</sup>) was recorded at absolute control (B<sub>5</sub>) plot.

Adoption of different irrigation and nutrient management practices had great interaction effect on yield of rice. Grain yield (8571 kg ha<sup>-1</sup>) and straw yield (9347 kg ha<sup>-1</sup>) was obtained higher in Continuous flooding coupled with the application of 150% RDF (100% N through inorganic and 50% N through GLM) (A<sub>3</sub>B<sub>4</sub>). It was followed by irrigation at 10 cm depletion of field water tube along with 150% RDF (100% N through inorganic and 50% N through GLM) (A<sub>1</sub>B<sub>4</sub>) of about 7917 kg ha<sup>-1</sup> of grain and 8793 kg ha<sup>-1</sup> of straw yield. This could be due to increased water uptake and nutrient uptake under green leaf manure application. Lowest yield was evidenced with irrigation at 15 cm depletion of field water tube with absolute control (A<sub>2</sub>B<sub>5</sub>) recorded grain and straw yield of about 2806 and 3237 kg ha<sup>-1</sup>.

#### Consumptive use

Consumptive use depends on the irrigation frequency and quantity of water required by the crop (Sathish *et al.*, 2017a) [17]. Least consumptive use of 981 mm was obtained in irrigation at 15 cm depletion of field water tube (A<sub>2</sub>). Throughout the crop growth period, the consumptive use was obtained higher in (1348 mm) in continuous flooding (A<sub>3</sub>)

followed by irrigation at 10 cm depletion of field water tube ( $A_1$ ) of about 1163 mm. Maintaining water throughout the entire crop period and alternate day irrigations increased the water use (Mahajan *et al.*, 2012) [11]. Sathish *et al.*, (2017a) [17] also found similar results in their experiments. Among the nutrient management practices consumptive use of water was least (988 mm) in 100% RDF along with recommended GLM application ( $B_2$ ) and highest was accounted in absolute control ( $B_5$ ) 1456 mm. (Table 4).

Irrigation at 15 cm depletion of field water tube along with application of 100% RDF and recommended dose of GLM ( $A_2B_2$ ) registered lower consumptive use of water 791 mm and it was similar with irrigation at 15 cm depletion of field water tube with application of 150% RDF (100% N through inorganic and 50% N through application of GLM) ( $A_2B_4$ ) 817 mm (Table 4).

#### Water use efficiency (WUE)

Different irrigation regimes had significant effect on water use efficiency of the crop. It was higher 6.18 kg ha mm<sup>-1</sup> in irrigation at 15 cm depletion of field water tube ( $A_2$ ) followed by irrigation at 10 cm depletion of field water tube ( $A_1$ ) (5.61

kg ha mm<sup>-1</sup>) (Table 5). Maintenance of yield to an optimum level coupled with the reduction in water use increased the WUE (Sathish *et al.*, 2017a) [17]. Alternate wetting and drying of the fields led to good aeration of the soil and better root growth thereby increasing the WUE (Santheepan and Ramanathan, 2016) [16]. Lowest water use efficiency of about 5.21 kg ha mm<sup>-1</sup> was recorded in continuous submergence ( $A_3$ ). Higher consumption of water with corresponding increase in yield have led to decreased WUE (Santheepan and Ramanathan 2016) [16]. Water use efficiency (Table 5) was higher (7.97 kg ha mm<sup>-1</sup>) in 150% RDF (100% N through inorganic and 50% N through GLM) ( $B_4$ ) (Table 5) and it was similar (7.11 kg ha mm<sup>-1</sup>) with 125% RDF (100% N through inorganic and 25% N through GLM) ( $B_3$ ). Similar results were obtained by Kumar *et al.*, (2013) [9] and Parihar *et al.*, (1995). Lowest was registered in absolute control treatment ( $B_5$ ) of about 2.49 kg ha mm<sup>-1</sup>.

Substantial interaction effect was noted on WUE of rice crop. Higher WUE (Table 5) was obtained in irrigation at 15 cm depletion of field water tube along with 150% (100% N through inorganic and 50% N through GLM) ( $A_2B_4$ ) 9.12 kg ha mm<sup>-1</sup>.

**Table 1:** Effect of irrigation regimes and nutrient management practices on yield attributes

	Productive tillers m <sup>-2</sup>						No. of grains panicle <sup>-1</sup>						Filled grains panicle <sup>-1</sup>							
	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN	A <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN	A <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN
A <sub>1</sub>	293	311	321	331	198	291	A <sub>1</sub>	167	182	187	201	116	171	A <sub>1</sub>	157	166	176	192	107	160
A <sub>2</sub>	259	265	282	289	185	256	A <sub>2</sub>	153	177	183	194	105	162	A <sub>2</sub>	134	161	171	186	98	150
A <sub>3</sub>	308	319	326	337	205	299	A <sub>3</sub>	179	185	194	206	121	177	A <sub>3</sub>	162	174	183	198	102	164
MEAN	287	298	310	319	196		MEAN	166	181	188	200	114		MEAN	151	167	177	192	102	
	A	B	A at B	B at A				A	B	A at B	B at A				A	B	A at B	B at A		
SEd	8.9	8.3	8.5	8.2			SEd	5.5	5.1	4.9	4.8			SEd	5.1	4.8	4.9	4.5		
CD (p=0.05)	19.4	18	18.3	17.8			CD (p=0.05)	11.9	10.9	10.8	10.6			CD (p=0.05)	10.9	10.3	10.4	9.7		

**Table 2:** Effect of irrigation regimes and nutrient management practices on yield attributes

	Panicle length (cm)						1000 grain weight (g)						
	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN	A <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN
A <sub>1</sub>	19.7	21.4	23	24.6	17.4	21.22	A <sub>1</sub>	21.9	23.1	23.6	23.9	20.3	22.56
A <sub>2</sub>	18.3	19.1	21.5	22.1	16.1	19.42	A <sub>2</sub>	19.7	22.5	23.2	23.3	19.5	21.64
A <sub>3</sub>	20.9	22.6	23.7	25.2	18.2	22.12	A <sub>3</sub>	22.7	23.4	23.7	24.4	20.7	22.98
MEAN	19.63	21.03	22.73	23.97	17.23		MEAN	21.43	23.00	23.50	23.87	20.17	
	A	B	A at B	B at A				A	B	A at B	B at A		
SEd	0.69	0.8	0.6	0.6			SEd	0.62	0.61	0.7	0.69		
CD (p=0.05)	1.5	1.6	1.44	1.41			CD (p=0.05)	1.33	1.32	1.53	1.49		

**Table 3:** Effect of irrigation regimes and nutrient management practices on yield

	Grain yield kg ha <sup>-1</sup>						Straw yield kg ha <sup>-1</sup>						
	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN	A <sub>1</sub>	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN
A <sub>1</sub>	5435	6495	7518	7917	3611	6195.2	A <sub>1</sub>	6129	7285	8412	8793	4045	6932.8
A <sub>2</sub>	4396	6091	6869	7450	2806	5522.4	A <sub>2</sub>	5012	6914	7769	8361	3237	6258.6
A <sub>3</sub>	5617	7189	7868	8571	4544	6757.8	A <sub>3</sub>	6319	8013	8693	9347	5281	7530.6
MEAN	5149.3	6591.7	7418.3	7979.3	3653.7		MEAN	5820.0	7404.0	8291.3	8833.7	4187.7	
	A	B	A at B	B at A				A	B	A at B	B at A		
SEd	282.9	271.8	264.6	250			SEd	322.2	302.8	294	281.6		
CD (p=0.05)	614	581.7	568.8	532.5			CD (p=0.05)	689.5	651.1	629.2	602.7		

**Table 4:** Effect of irrigation regimes and nutrient management practices on consumptive use of water (mm)

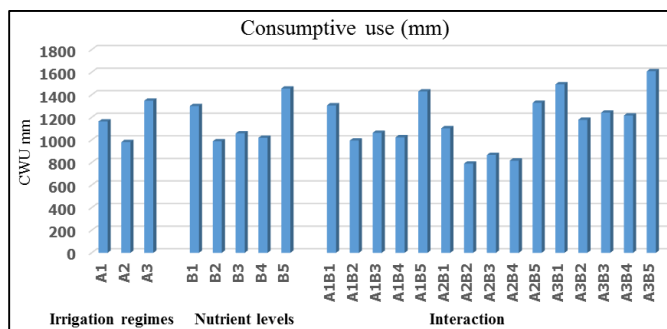
	Consumptive use (mm) *					
	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN
A <sub>1</sub>	1306	995	1063	1023	1429	1163
A <sub>2</sub>	1103	791	867	817	1329	981
A <sub>3</sub>	1492	1178	1242	1217	1609	1348
MEAN	1301	988	1057	1019	1456	

\* Data not statistically analysed

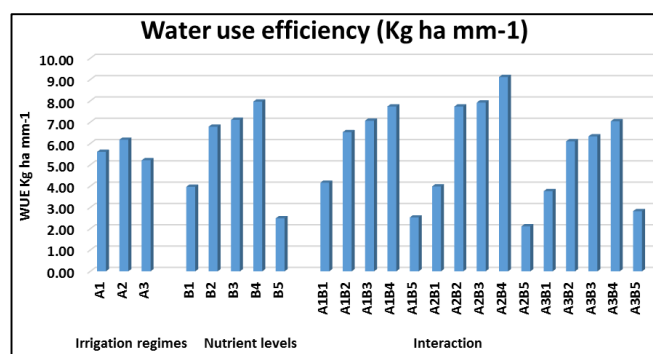
**Table 5:** Effect of irrigation regimes and nutrient management practices on Water use efficiency (kg ha-mm<sup>-1</sup>)

	Water use efficiency (kg ha-mm <sup>-1</sup> )					
	B <sub>1</sub>	B <sub>2</sub>	B <sub>3</sub>	B <sub>4</sub>	B <sub>5</sub>	MEAN
A <sub>1</sub>	4.16	6.53	7.07	7.74	2.53	5.61
A <sub>2</sub>	3.99	7.74	7.92	9.12	2.11	6.18
A <sub>3</sub>	3.76	6.10	6.33	7.04	2.82	5.21
MEAN	3.97	6.79	7.11	7.97	2.49	
	A	B	A at B	B at A		
SEd	0.19	0.15	0.16	0.14		
CD (p=0.05)	0.40	0.31	0.34	0.30		





**Fig 1:** Effect of irrigation regimes and nutrient levels on Consumptive water use (mm).



**Fig 2:** Effect of irrigation regimes and nutrient levels on Water use efficiency (Kg ha mm<sup>-1</sup>).

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