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**Anju K Baby**

PG Scholar, Department of  
Agronomy, Agricultural College  
and Research Institute,  
Killikulam, Vallanadu Post,  
Thoothukudi, Tamil Nadu, India

**M Hemalatha**

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

**M Joseph**

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

**S Jothimani**

Professor, Department of Soil  
Science and Agricultural  
Chemistry Agricultural College  
and Research Institute,  
Killikulam, Vallanadu post,  
Thoothukudi, Tamil Nadu, India

**Corresponding Author:****Anju K Baby**

PG Scholar, Department of  
Agronomy, Agricultural College  
and Research Institute,  
Killikulam, Vallanadu Post,  
Thoothukudi, Tamil Nadu, India

## Influence of various irrigation regimes on growth and yield of wet seeded rice (*Oryza sativa* L.) under Thamirabarani command area

Anju K Baby, M Hemalatha, M Joseph and S Jothimani

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**Abstract**

Field trial was conducted at Agricultural College and Research Institute, Killikulam during *Pishanam* 2019-2020 to assess the impact of various irrigation regimes on growth and yield of wet seeded rice under the Tamirabarani command area. Randomized block design was followed with ten irrigation treatments namely irrigation at 5 cm, 10 cm and 15 cm depletion of water level, irrigation at 10 cm depletion up to maximum tillering (MT) and thereafter 5 cm depletion 10 days prior to harvest (DPH), irrigation at 15 cm depletion up to MT and thereafter 5 and 10 cm depletion 10 DPH, Alternate wetting and drying (AWD), AWD up to MT and thereafter 5 and 10 cm depletion 10 DPH and Continuous flooding. Field water tube (FWT) was used to check the field water status. Observations on growth parameters like plant height, number of tillers m<sup>-2</sup> and dry matter production were recorded during active tillering, panicle initiation and at harvest stages. Grain and straw yield were also recorded. AWD (T7) recorded higher plant height, number of tillers m<sup>-2</sup> and dry weight in all the stages and it was on par with irrigation at 5 cm depletion of water in FWT (T1). AWD also registered greater grain and straw yield, and was similar to irrigation at 5 cm depletion of water in FWT.

**Keywords:** AWD irrigation regimes using FWT, growth and yield of wet seeded rice

**Introduction**

Rice (*Oryza sativa* L.) is considered the staple food for more than 60% of the world's population residing in Asia, supplementing about 35 - 60% of their total calorie uptake. Rice is a crucial component for providing food security to the rapidly increasing population. About 44.17 million hectare area in India is under rice, with an average production of 116.5 million tonnes and productivity of 2.64 tonnes per hectare (India Stat, 2019) [7]. India should produce an additional yield of 1.7 million tonnes every year to ensure national food security (Dass and Chandra, 2012) [5]. There is little land available to expand rice cultivation, means that productivity should be increased within the limited land area available using better rice genotypes and improved production practices.

Increase in water shortage and competition for water are major constraints in rice cultivation. Transplanting is the most prevalent and traditional method of rice establishment in low lying areas. In this method, rice requires about 800 to 5000 liters of water to produce one kilogram of rice (Bouman, 2009) [3]. Ye *et al.*, 2016 [14] evaluated the transition from traditionally transplanted rice to direct seeded rice (dry and wet) and reported 10.8% higher yield and 13.4% greater water productivity in wet seeded rice.

Assuming an average yield of 5 tonnes per hectare in Asia, the water productivity of irrigated rice is only about 0.15 kg of milled rice per m<sup>3</sup> of water. A 10 per cent increase in irrigation efficiency can help bring additional 14 million ha area under irrigation. To improve the water productivity of rice, alternate water saving methods and practices have to be developed and adopted. Compared to farmers practice of continuous flooding, safe AWD saves as much as irrigation water (30%) without any reduction in yield and increases farmers income by 30% (Lampayan, 2013) [9]. Field water tube with intermittent irrigation reduced the total consumption of water with lesser number of irrigations. This technique also increased the water use efficiency and water productivity of rice (Sureshkumar and Pandian, 2017) [13]. Proper irrigation management under AWD using field water tubes in wet seeded rice can increase water productivity and reduce total irrigation water input.

Hence this study was conducted to evaluate the performance of wet seeded rice under various AWD irrigation regimes in the Tamirabarani tract.

## Materials and Methods

The field experiment was conducted at Agricultural College and Research Institute, Killikulam, Tamil Nadu during *Pishanam* season (2019 – 2020). The soil was sandy clay loam in texture with pH of 7.15, EC of 0.12 dSm<sup>-1</sup> and organic carbon content of 6.3 g kg<sup>-1</sup>. The soil was low in available nitrogen (230.9 kg ha<sup>-1</sup>), medium in available phosphorus (18.5 kg ha<sup>-1</sup>) and medium in available potassium (227.9 kg ha<sup>-1</sup>). The experiment was laid out in randomized block design with ten irrigation treatments and replicated thrice. The treatments imposed were irrigation at 5cm depletion of water level (T1), irrigation at 10 cm depletion of water level (T2) and irrigation at 15 cm depletion of water level (T3), irrigation at 10 cm depletion up to maximum tillering and thereafter 5 cm depletion 10 days before harvesting (T4), irrigation at 15 cm depletion up to maximum tillering and thereafter 5 cm depletion 10 days before harvesting (T5), irrigation at 15 cm depletion up to maximum tillering and thereafter 10 cm depletion 10 days before harvesting (T6), Alternate wetting and drying [AWD](T7), AWD up to maximum tillering and thereafter 5 cm depletion 10 days before harvesting (T8), AWD up to maximum tillering and thereafter 10 cm depletion 10 days before harvesting (T9) and Continuous flooding (T10). Field water tube was installed in all treatment plots to monitor the water level and Parshall flume was used to quantify the irrigation water applied.

All treatments were irrigated at 5 cm height from the soil surface level when they reached the required depletion. In AWD and continuous flooding treatments, 5 cm depth irrigation was given one day after disappearance of ponded water and on the day of disappearance of ponded water, respectively. Variety used for the study was ASD 16. All other agronomic practices like nutrient management, weed control, plant protection measures and harvesting operation were made similar for all treatments. Various observations such as plant height, number of tillers per m<sup>2</sup> and dry matter production were recorded at active tillering (AT), panicle initiation (PI) and harvest stages. Grain and straw yield were computed separately for each plot after harvest and the results were presented at 14% moisture.

## Results and Discussion

### Influence of irrigation regimes on growth of wet seeded rice Plant height (cm)

Influence of the varying irrigation schedules on plant height was recorded in active tillering (AT), panicle initiation (PI) and harvest stages. Plants in treatment plots of AWD (T7) showed increased height of 63.6, 98.2 and 125.1 cm and it was on par with irrigation at 5 cm depth depletion in FWT (T1) recorded 62.9, 97.8 and 123.8 cm at AT, PI and at harvest stages respectively. Plant height observed in these treatments were higher than that of plant height in continuous flooding at all the stages. These were in accordance with the findings of several researchers who documented production of taller plants with optimum irrigation regime (Chowdhury *et al.*, 2014) [4]. Plant height was also recorded greater in irrigation at 10 cm depletion up to maximum tillering and thereafter 5 cm depletion up to 10 DPH (T4) (61.8, 84.7, 114.7 cm at AT, PI and at harvest stages, respectively) and AWD up to maximum tillering and thereafter 5 cm depletion

up to 10 DPH (T8) (60.7, 84.2 and 114.1 cm at AT, PI and at harvest stage, respectively), when compared to the other irrigation combinations. These water regimes were found to be on par with each other. Sufficient soil moisture promotes plant metabolism and ensures optimum resource allocation, which is further amplified due to adequate aeration in between the irrigation cycles effecting in taller plants (Abou-Khalifa, 2010) [1].

At active tillering, panicle initiation and harvest stages, treatment plots under irrigation at 15 cm depth depletion of water in FWT (T3) produced shorter plant height of 54.7, 69.8 and 99.1 cm, respectively on comparison with all the other irrigation schedules, which was resemblant to plant height in irrigation at 15 cm depletion up to maximum tillering and thereafter 10 cm depletion up to 10 DPH (T6). Sariam and Anuar (2010) [12] suggested water deficit at any stage before anthesis resulted in shorter plants. This reason may be attributed to the outcome obtained in treatments with poor performance.

### Number of tillers m<sup>-2</sup>

Tiller number in wet seeded rice was unquestionably influenced by the irrigation regimen in all three stages *viz.*, active tillering, panicle initiation and harvest stages. Significantly higher number of tillers (284, 331 and 356 tillers m<sup>-2</sup> at AT, PI and at harvest stages, respectively) were observed in AWD (T7) over the continuous flooding (257, 304 and 326 tillers m<sup>-2</sup>). Irrigation on 5 cm depletion of water level in FWT (T1) also produced notably augmented tillers which was equivalent to the AWD treatment at all the three observed stages. Favorable moisture regimes enabled the abundant growth of plants by providing conducive microclimate for efficiently utilizing growth promoting minerals ultimately producing more tillers (Kumar *et al.*, 2014) [8]. Number of tillers were also notably greater in irrigation at 10 cm depletion up to maximum tillering and thereafter 5 cm depletion up to 10 DPH (T4) (238, 282 and 301 tillers m<sup>-2</sup> at AT, PI and harvest stages, respectively) and AWD up to maximum tillering and thereafter 5 cm depletion up to 10 DPH (T8) (226, 275 and 295 tillers m<sup>-2</sup>). These irrigation regimes treatments were found to be on par with each other. Properly accomplished AWD treatments during early stages encouraged greater tillering density in direct seeded rice, creating an efficient canopy architecture (Gill *et al.*, 2011) [6].

Decreased tiller production was noticed in irrigation at 15 cm depth depletion of water in FWT (T3) (168, 207 and 212 tillers m<sup>-2</sup> at AT, PI and harvest stages, respectively). This result coincided with number of tillers per m<sup>-2</sup> recorded in irrigation at 15 cm depletion up to maximum tillering and thereafter 10 cm depletion up to 10 DPH (T6) (172, 212 and 233 tillers m<sup>-2</sup>). Water deficit in soil, especially during leaf elongation process, disrupted plant water balance leading to decrease in leaf initiation which caused insufficient sites for tiller formation, thus reducing tiller number (Mote *et al.*, 2017) [10].

### Dry matter production

Dry matter production of wet seeded rice due to various treatments was recorded during active tillering, panicle initiation and harvest stages. DMP recorded in the irrigation regime of AWD (T7) (3695, 8296 and 15300 kg ha<sup>-1</sup> at AT, PI and at harvest stages, respectively) was greater than that of continuous flooding. Irrigation at 5 cm depletion of water level in FWT (T1) registered dry matter of 3479, 8040 and

15010 kg ha<sup>-1</sup> and it was on par with the AWD one day after disappearance of ponded water. Kumar *et al.* (2014)<sup>[8]</sup> and Chowdhury *et al.* (2014)<sup>[4]</sup> also discussed similar results; but they found dry matter production in irrigation at 5 cm depletion in FWT to be lower than that of the AWD treatment, which was found to be on par in this study.

Irrigating at 10 cm depletion up to maximum tillering and thereafter 5 cm depth depletion up to 10 DPH (T4) also gave better DMP than all the other combination treatments except AWD up to maximum tillering and thereafter 5 cm depletion up to 10 DPH (T8).

This treatment may have achieved the irrigation threshold to achieve better growth and yield parameters. Better tiller production and shoot growth during the vegetative phase and consequent alterations in the reproductive stage due to production of yield attributes increased the shoot weight (Baligar and Fageria, 2007)<sup>[2]</sup>.

Irrigation of 15 cm depletion in FWT (T3) reported poorer DMP (2646, 4986 and 9954 kg ha<sup>-1</sup> at AT, PI and harvest stages, respectively), which was on par with irrigation at 15 cm up to maximum tillering and thereafter 10 cm depth until 10 DPH (T6).

This may be due to increased water stress to the plant during the leaf expansion phase which reduced accumulation of photosynthates in the plant, in turn reducing the dry matter.

#### Influence of irrigation regimes on grain and straw yield

Irrigation regimes significantly affected the grain and straw yield of wet seeded rice. Among the treatments, alternate wetting and drying (T7) yielded maximum grain and straw yield 7227 and 7957 kg ha<sup>-1</sup>, respectively over continuous flooding (6482 and 7141 kg ha<sup>-1</sup>, respectively).

Irrigation at 5 cm depletion of water in the field water tube (T1) recorded grain and straw yield of 6992 and 7675 kg ha<sup>-1</sup>, respectively and it was on par with the AWD one DADPW regime. Zhang *et al.* (2009)<sup>[16]</sup> reported similar increase in biological yield under alternate wetting and drying regimes.

Irrigation at 10 cm depletion up to maximum tillering stage and thereafter 5 cm depth depletion up to 10 DPH (T4) registered grain and straw yield of 6012 and 6632 kg ha<sup>-1</sup>, respectively. However, it was similar to AWD up to maximum tillering and there after 5 cm depth depletion in FWT (T8).

This performance of combined AWD may be due to proper and timely water availability in the rhizosphere during vegetative and flowering stages, which enabled efficient absorption of soil nutrients, triggering an increase in tiller number, sink strength and higher dry matter production. These factors were said to be positively correlated directly with nitrogen accumulation in plant and indirectly to yield (Yoshida *et al.*, 2006)<sup>[15]</sup>.

Irrigation at 15 cm depletion of water level in FWT (T3) registered lower grain and straw yield (4198 and 5004 kg ha<sup>-1</sup>, respectively) and it was on par with irrigation at 15 cm depletion up to maximum tillering and thereafter 10 cm depletion up to 10 DPH (T6).

The deficit water input during the initial growth stages and the water sensitive heading stage may have caused noticeable deduction in yield attributing characters which in turn determine the overall economic yield (Rahman *et al.*, 2020)<sup>[11]</sup>.

The harvest index did not show any significant variation in wet seeded rice due to various irrigation regimes and however it ranged from 0.45 to 0.47.

**Table 1:** Influence of irrigation regimes on plant height (cm) of wet seeded rice

Treatment	Active tillering	Panicle initiation	At harvest
T1	62.9	97.8	123.8
T2	55.0	76.7	112.3
T3	54.7	69.8	99.1
T4	61.8	84.7	114.7
T5	55.8	77.5	113.6
T6	54.9	70.1	103.7
T7	63.6	98.2	125.1
T8	60.7	84.2	114.1
T9	55.3	77.1	112.9
T10	62.1	91.2	115.2
SEd	1.94	2.95	3.87
CD (p=0.05)	4.2	6.4	8.4

**Table 2:** Influence of irrigation regimes on number of tillers m<sup>-2</sup> of wet seeded rice

Treatment	Active tillering	Panicle initiation	At harvest
T1	276	326	349
T2	192	235	258
T3	168	207	212
T4	238	282	301
T5	206	252	269
T6	172	212	233
T7	284	331	356
T8	226	275	295
T9	198	244	267
T10	257	304	326
SEd	8.02	9.54	10.65
CD (p=0.05)	17.4	20.7	23.1

**Table 3:** Influence of irrigation regimes on Dry matter production (kg ha<sup>-1</sup>) of wet seeded rice

Treatment	Active tillering	Panicle initiation	At harvest
T1	3479	8040	15010
T2	2772	5611	11300
T3	2646	4986	9954
T4	3154	6912	13053
T5	2972	6048	11587
T6	2744	5088	10114
T7	3695	8296	15300
T8	2999	6588	12564
T9	2916	5873	11482
T10	3310	7496	14087
SEd	108.1	242	414.4
CD (p=0.05)	230.4	520.3	895.2

**Table 4:** Influence of irrigation regimes on yield (kg ha<sup>-1</sup>) of wet seeded rice

Treatment	Grain yield (kg ha <sup>-1</sup> )	Straw yield (kg ha <sup>-1</sup> )	Harvest index
T1	6992	7675	0.47
T2	4928	5571	0.47
T3	4198	5004	0.45
T4	6012	6632	0.47
T5	5366	5991	0.47
T6	4338	5051	0.46
T7	7227	7957	0.47
T8	5876	6519	0.47
T9	5071	5784	0.46
T10	6482	7141	0.47
SEd	200.6	236.2	-
CD (p=0.05)	431.2	510.1	-

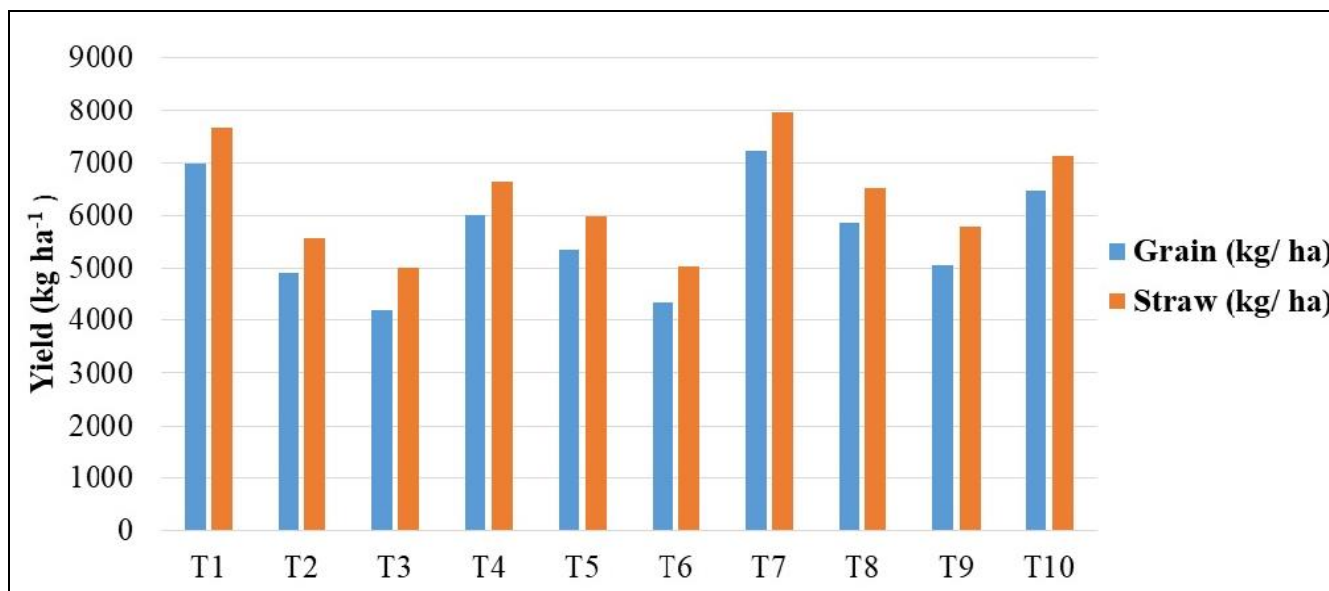


Fig 1: Influence of irrigation regimes on grain and straw yield of wet seeded rice

### Conclusion

The current study showed that different irrigation schedules influenced the growth parameters and yield of wet seeded rice, even when all other management practices are kept the same. Alternate wetting and drying treatment (T7) and irrigation at 5 cm depth of water level in field water tube (T1) gave better outcomes in the case of plant height, number of tillers  $m^{-2}$  and dry matter production at active tillering, panicle initiation and at harvest stages. The same treatments produced higher grain and straw yield over the continuous flooding. Hence these irrigation regimes may be suggested as alternatives to continuous flooding. Irrigation schedule of irrigation at 10 cm depletion up to maximum tillering and thereafter 5 cm depletion up to 10 days before harvesting (T4) may also be suggested, especially in area of restricted water availability.

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