Impact of Alternate Wetting and Drying Irrigation (AWDI) on water saving and yield of transplanted rice through large scale demonstration

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ABSTRACT:

Aims: The aim of this study is to evaluate the impact of Alternate Wetting and Drying Irrigation (AWDI) on water conservation and rice yield in transplanted rice through large-scale demonstration trials.

Place and Duration of Study: Mettur-Noyyal confluence sub basin areas of Tamil Nadu by the Tapioca and castor Research station, Yethapur for the past five years (2019-2023).

Methodology: For adopting the safe AWDI, the depth of ponded water on the field is monitored using a 'Field Water Tube' which is made of 40-cm long plastic pipe having a diameter of 15 cm which is perforated with holes on all sides.

Results: The AWDI technology consumed ranges between 871 mm to 950 mm of irrigation water, higher water use efficiency (6.22 to 7.53 $kg ha^{-1} mm^{-1}$) and number of irrigations were recorded between 22 to 30. By adopting AWDI in rice recorded highest rice yield of 7045 kg ha^{-1} compared to conventional method (5927 kg ha^{-1}) among the all the experiments. The highest gross returns (Rs. 131927 ha^{-1}), net return (Rs. 77438 ha^{-1}) and BCR (2.99) were recorded in adoption of AWDI.

Conclusion: The Alternate Wetting and Drying Irrigation (AWDI) will be an appropriate technology for water saving in rice. This technology saves up to 49 percent of irrigation water without any yield penalty and 12 irrigations will be reduced under AWDI when compared to farmers practice.

Keywords: Rice, Alternate Wetting and Drying Irrigation, Field Water Tube, Water Use Efficiency

1. INTRODUCTION

The water crisis is a major concern as the water demand in growing areas is gradually increasing. The main water sources can no longer meet the increasing demand for the domestic, industrial and agricultural sectors. In agricultural areas, water is a prime factor and important resource needed for proper crop growth, particularly for water-intensive crops such as rice (Jury and Vaux, 2007). Farmers usually adopt conventional practices where paddy is grown under continuously flooded conditions. This traditional practice commonly requires standing water per season, ranging from 700 mm to 1,500 mm (Oliver et al., 2010). Nonetheless, this practice has a long-term issue concerning the environmental effect of unnecessary irrigation water consumption. International Rice Research Institute (IRRI) introduced a advanced technology approach focusing on water-saving management

Comment [AA1]: Ensure consistency in terms like "AWDI" (used in multiple places) and "Alternate Wetting and Drying Irrigation." Consider using one consistently after introducing the abbreviation.

Comment [AA2]: Be specific about the location: Mention the state and country (Tamil Nadu, India) for clarity, as the audience may not be familiar with the region.

Comment [AA3]: Use a consistent format for the duration: "from 2019 to 2023" instead of "for the past five years (2019-2023)."

Comment [AA4]: Avoid repeating "recorded" multiple times; consider synonyms like "achieved" or "observed."

Comment [AA5]: Suggestion: Rephrase for clarity: "Adopting AWDI in rice resulted in the highest yield of 7045 kg ha-1 compared to the conventional method, which produced 5927 kg ha-1 across all experiments."

Comment [AA6]: Suggestion: Simplify and correct grammar: "This technology saves up to 49% of irrigation water without reducing yield, and it reduces the number of irrigations by 12 compared to farmers' practices."

Comment [AA7]: Need a new research between 2020 to 2024 because the review is old

Comment [AA8]: Suggestion: "This traditional practice typically requires 700 to 1,500 mm of standing water per season (Oliver et al., 2010)."

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practice, known as the "Alternate Wetting and Drying (AWD) technique" (Nelson et al., 2015). The enforcement of AWD is farmer-friendly. Water conservation technology only needs a proper field water tube made from a low-cost material, such as bamboo and polyvinyl chloride (PVC). A field water tube is used to monitor the standing water level. The paddy field is flooded with irrigation water and is allowed to dry out to a certain ground depth before the irrigation water is reapplied again. In AWD practices, less irrigation water input is required. Past researchers (Carrijo et al., 2017; Mote et al., 2021; Chapagain et al., 2011; Howell et al., 2015; Sriphirom et al., 2019) have reported and acknowledged this technique and found that by using AWD practice, there is no significant decrease in yield compared to continuous flooded practice. In AWD irrigation, not only does a reduction of up to 15-30 per cent of total irrigation water input, but the total water productivity is also increased, and the same goes for the nutrient uptake (Wichaidist et al., 2023). AWD irrigation has been widely used worldwide and is one of the popular methods in paddy cultivation. AWD has promoted water productivity in rice irrigation relative to conventional irrigation (Arai et al., 2021; Pascual and Wang, 2017; Bwire et al., 2024; Gao et al., 2024; Ishfaq et al., 2020). In addition, Norton et al. (2017) ascertained in their report that AWD increased the total grain mass due to the high number of productive tillers. Sekhar et al. (2022), who mentioned that the AWD practice positively affects the tiller, panicle numbers, and grain yield. During *kharif* season in Tiruvannamalai district, more than 40,000 hectares of land is under paddy cultivation. The indiscriminately use of irrigation water to the paddy crop by continues flooding and farmers were lack of awareness about AWD through Pani Pipe were identified as major problem. By considering the above problems, present demonstration was conducted to create an awareness to transplanted paddy farmers of Tamil Nadu Irrigated Agriculture Modernization Project Phase-II, Aliyar sub basin of Tiruvannamalai district about judicious use of irrigation water by using Pani Pipe. In order to address climate change in rice production, a climate-smart strategy that presents both adaptation and mitigation benefits is essential. Numerous water-saving techniques have been introduced and documented since time immemorial, for example, intermittent irrigation, drip irrigation, deficit water regime, a system of rice intensification (SRI) and alternate wetting and drying (AWD). AWD is the most popular water-saving technology adopted to improve water use efficiency (Haonan et al. 2023). Hence this study evaluate the "Impact of Alternate Wetting and Drying Irrigation (AWDI) on water saving and yield of transplanted rice through large scale demonstration".

Comment [AA9]: Correction: "The International Rice Research Institute (IRRI) introduced an advanced technological approach focused on water-saving management practices..."

Comment [AA10]: The phrase "irrigation water" is repeated multiple times. Consider varying the language for better readability.

2. MATERIAL AND METHODS

Comment [AA11]: The paragraph is dense and could benefit from better structuring. Divide it into smaller paragraphs to separately address:
Study design and duration.
Locations and participants.
Description of treatments and methods.
Supporting research from CWGS.

Large scale on farm demonstration was carried out in irrigated lowlands using the alternate wetting and drying irrigation (AWDI) method for 5 consecutive years during the period of 2019-2020 to 2023-2024 through Tamil Nadu Irrigated Agriculture Modernization Project (TNIAMP) Phase-II, Mettur-Noyyal sub basin by Tapioca and Castor Research Station, Yethapur, Salem, Tamil Nadu. The demonstration on AWDI with field water tube in transplanted rice was carried out in Salem, Namakkal and Dharmapuri districts including four villages with 277 farmers holdings covering the areas of 326 ha. These demonstrations took place at the fields of farmers in the village of K.N.Puthur, Alamarathupatti, Lakkampatti, Neethipuram, Perumbalai, Avadathur, Periyasoragai, Vanavasi, Arasiramani, Koneripatti and Thevur in the Salem, Namakkal and Dharmapuri district of Tamil Nadu, India. Two treatments such as :T1-Conventional method like farmer practice, T2- AWDI method (Field Water tube) was imposed in larger way. Non-adoption of improved water management practices during critical stages of crop growth especially tillering stage, milky stage and dough stage resulted in more number of unproductive tiller and chaffy grains. For adopting the safe AWDI, the depth of ponded water on the field is monitored using a 'Field Water

Comment [AA12]: Correction: "A large-scale on-farm demonstration was conducted in irrigated lowlands using the Alternate Wetting and Drying Irrigation (AWDI) method over five consecutive years (2019–2024) as part of the Tamil Nadu Irrigated Agriculture Modernization Project (TNIAMP) Phase-II in the Mettur-Noyyal sub-basin, implemented by the Tapioca and Castor Research Station, Yethapur, Salem, Tamil Nadu."
Fix grammatical errors and improve readability.

Tube' which is made of 40-cm long plastic pipe having a diameter of 15 cm which is perforated with holes on all sides. The tube is dug in the soil so that 15 cm protrudes above the soil surface and the soil from inside is removed so that the bottom of the tube is visible. The water table inside the tube is to be same as outside the tube. The results of network experiments on safe AWDI conducted by the Centre for Water and Geospatial Studies (CWGS) of Tamil Nadu Agricultural University for the past five years, revealed that safe AWDI of 10 cm depletion in light soils and 15 cm in heavy soils may be adopted in Mettur Noyal sub basin areas as safe AWDI for improving the water use efficiency in transplanted rice. The ponding depth was 5cm after reaching the threshold level.

Comment [AA13]: The description of the "Field Water Tube" is detailed but could be more concise. For example:
"A Field Water Tube, made of a 40-cm long perforated plastic pipe with a 15-cm diameter, was installed with 15 cm protruding above the soil surface. The tube allows monitoring of water levels, ensuring the water table inside matches the outside."

Comment [AA14]: The results from CWGS are mentioned but not directly linked to the study's methodology. Clarify whether these results informed the demonstration or were evaluated separately.

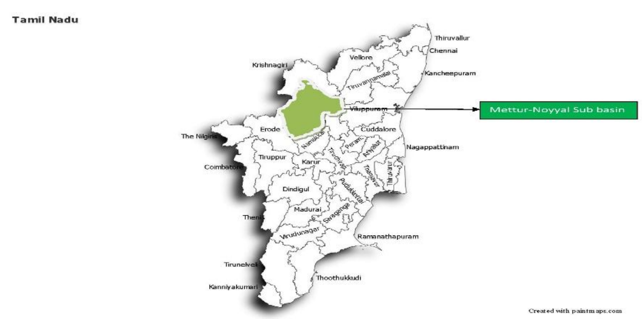

Figure 1: Map ofMettur-Noyyal sub basin

How to implement AWD?

A practical way to implement AWD safely is by using a 'Field Water Tube' (Pani Pipe) to monitor the water depth on the field. The Field water tube will be placed @ 3 per hectare since most of the paddy field in this Ayacut are fragmented. Field Water Tube (Fig. 2) made up of PVC. A few weeks after transplanting, AWD was initiated. When there are a lot of weeds, AWD is delayed for two to three weeks in order to help the ponded water suppress the weeds and increase the effectiveness of the herbicides. The large scale demonstrations was conducted in order to investigate the technology gap between the potential yield and demonstrated yield, the Water Use efficiency between the demonstrations and conventional method, to find out the feasibility and efficiency of field water tube for alternate wetting and drying irrigation regime management in transplanted rice and tofind out the optimum decline in water level to optimize the water use for higher yield andwork out the water productivity.

Comment [AA15]: The mention of "3 per hectare" is precise, but it would be beneficial to explain why this specific density is recommended and how it ensures effective monitoring in fragmented fields.

Comment [AA16]: The objectives listed are relevant and well-aligned with the goals of AWD implementation. However, they are mentioned in a single, long sentence. Breaking them into bullet points or separate sentences would enhance readability.

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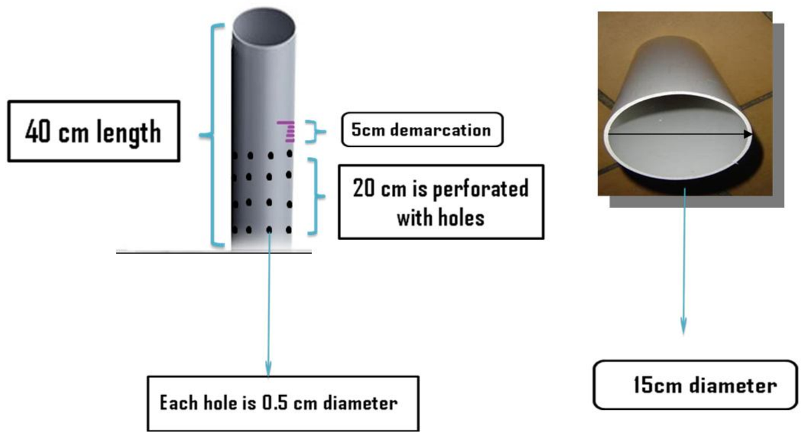

*Note the holes on all sides up to 15 cm height.

Figure 2: Field water tube

Data Analysis

The yield data was obtained from both the demonstration and conventional (farmer practice) method using the random crop cutting method. Qualitative data was converted to quantitative form and expressed as percentage increase in yield. The data was further analysed by using statistical tools.

3. RESULTS AND DISCUSSION

The supervision of the Tapioca and Castor Research Station, Yethapur, TNIAMP Phase II Mettur-Noyyal sub basin scientist crop yield was harvested accordingly. The present study revealed that the grain yield, extension gap, technology gap, economic analysis and water saving technology through the AWDI method using pani pipe were demonstrated in farmer's holdings.

Yield Analysis

The average grain yield under demonstrated plots was 7045, 5812, 5915, 6028 and 5074 kg/ha with an average of 5975 kg/ha from the years 2019-2020 to 2023-2024 respectively when compared with farmers practices of 5927, 5304, 5271, 5373 and 4149 kg ha^{-1} with an average of 5205 kg ha^{-1}(Tab.1). The comparison between the grain yield of demonstrated plots and farmers practice revealed that the average yield of demonstrated plots was 14.2 percent (Fig.3) higher than that of farmer practice. The higher yield observed in the demonstration plots could be a result of improved root system development caused by alternate wetting and drying irrigation, leading to a greater number of tillers per square meter and subsequently higher yields.

Table 1. Influence of Yield ($kgha^{-1}$) on AWDI in transplanted rice

Comment [AA17]: The term "random crop cutting method" is mentioned, but a brief explanation of how this method is implemented would help readers unfamiliar with it. For instance, specify the number of samples taken, their size, and the criteria for selection.

Comment [AA18]: The phrase "qualitative data was converted to quantitative form" is somewhat vague. It would be helpful to explain what qualitative data was collected and how it was quantified.

Comment [AA19]: The mention of "statistical tools" is too general. Specify the tools or methods used, such as ANOVA, t-tests, regression analysis, etc. This will enhance the scientific rigor and transparency of the methodology.

Comment [AA20]: The claim that the average yield in the demonstration plots was 14.2% higher than that of the farmer practices is valuable. However, it would be helpful to provide some context or explanation of why this percentage difference is significant. For example, how does this compare to typical yield variations in the region or under similar conditions?

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Year	Area (ha)	Yield ($kg ha^{-1}$)	
		AWDI	Conv.
2019	50	7045	5927
2020	80	5812	5304
2022	80	5915	5271
2022	80	6028	5373
2023	36	5074	4149
Average		5975	5205

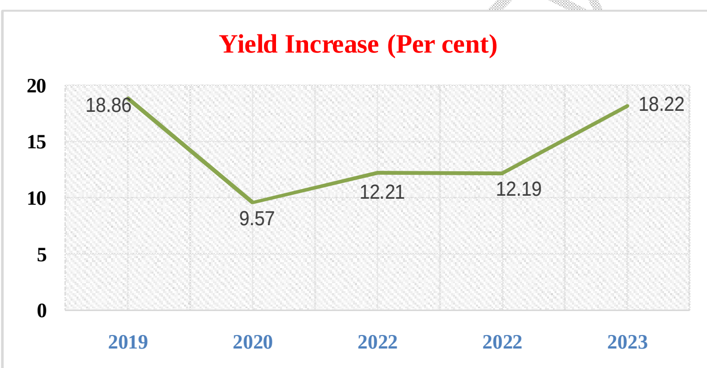

Figure 3. Impact of adapting AWDI practice on yield increase (per cent)

Economic analysis

The demonstration plots using alternate wetting and drying irrigation have demonstrated a higher economic return compared to traditional methods. This is primarily due to the increased yield achieved through improved root development and a higher number of tillers per square meter. Additionally, the reduced water consumption associated with alternate wetting and drying irrigation can lead to lower operational costs and potentially higher profits (Leon and Izumi, 2022).

The average net return over the past five years for the demonstration plots was Rs.72,784 ha^{-1} and the farmer practice revealed that the average net return over the past five years was Rs.56,625ha^{-1}. The average net return over the past five years for the demonstration plots using alternate wetting and drying irrigation was significantly higher than that of traditional methods. The benefit-cost ratio (BCR) of the alternate wetting and drying irrigation method (2.45) was greater than that of the traditional method (1.94) (Table 2)

Table 2. Effect of AWDI on Economics in transplanted rice

Comment [AA21]: a more detailed explanation of the factors contributing to this increase in net return would be helpful

Comment [AA22]: it would be valuable to provide more context about what these values represent in terms of real-world impact. For example, how do these BCR values compare to other water-saving technologies in rice farming? Additionally, including the cost of implementing AWD (e.g., for the field water tube or other infrastructure) would offer a more comprehensive understanding of the financial feasibility.

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Year	Area (ha)	Cost of cultivation (Rsha^{-1})		Gross Return (Rsha^{-1})		Net Return (Rsha^{-1})		BCR	
		AWDI	Conv.	AWDI	Conv.	AWDI	Conv.	AWDI	Conv
2019	50	38809	36349	116247	97796	77438	61447	2.99	1.88
2020	80	41789	45502	62305	52975	60516	44473	2.34	1.97
2021	80	45241	48401	106484	94880	61243	46479	2.35	1.96
2022	80	48104	50286	71395	59419	73291	59133	2.26	1.89
2023	36	40482	36539	131914	108133	91432	71594	2.32	2.00
Average		42885	43415	97669	82640	72784	56625	2.45	1.94

Effect of AWDI on irrigation frequency, water use rate (mm) and Water Use Efficiency (kgha^{-1}mm^{-1}) in Transplanted rice

Alternate wetting and drying (AWD) irrigation is a water-saving technique that involves allowing the soil to dry out periodically between irrigation events. This practice mimics natural rainfall patterns and encourages deeper root development, enabling plants to access water stored in the lower soil profile. By reducing the frequency of irrigation, AWD can significantly reduce water consumption. Additionally, this method can help improve soil health by promoting beneficial microbial activity and reducing the risk of water logging (Soliman et al. 2024). As a result, AWD can lead to higher water use efficiency, lower irrigation frequency, and reduced water use rates compared to conventional irrigation methods, such as flooded irrigation. Alternate Wetting and Drying Irrigation (AWDI) offers several advantages over conventional methods like flooded irrigation, particularly in terms of water conservation and soil health. By allowing the soil to dry out periodically between irrigation events, AWDI significantly reduces water consumption compared to continuous flooding. This practice encourages deeper root development, enabling plants to access water stored in the lower soil profile and reducing reliance on surface irrigation. Additionally, AWDI can help improve soil structure by promoting beneficial microbial activity and reducing the risk of water logging. This can lead to enhanced nutrient cycling and increased crop yields. Furthermore, AWDI can help mitigate greenhouse gas emissions, such as methane, that are often associated with flooded irrigation (Wijesundara, 2024). Overall, AWDI is a more sustainable and efficient irrigation method that can contribute to improved agricultural productivity while conserving water resources. The AWDI method required only 27 irrigations, significantly fewer than the 39 irrigations needed in conventional methods. The AWDI method demonstrated a significant reduction in average water use rate, requiring only 910 mm of water per unit area compared to the 1394 mm needed in conventional methods. This substantial decrease in water consumption highlights the efficiency of AWDI in optimizing water usage for agricultural production. The demonstrated method exhibited a significantly higher average water use efficiency of 6.78 kg ha^{-1}mm^{-1} (Table 3) compared to the conventional method, which averaged 3.92 kg ha^{-1}mm^{-1}. This substantial improvement of 72.7 per cent indicates that the demonstrated method was more effective in converting water into crop yield, ultimately reducing water consumption and improving agricultural productivity.

Comment [AA23]: the text provides a solid overview of the benefits of AWD, more detailed data on the long-term sustainability of the practice would be valuable. For instance, how does AWD impact soil health over multiple seasons? Are there any potential drawbacks or challenges associated with AWD, such as the need for more precise monitoring or potential negative effects on certain crops?
A discussion on the cost-benefit analysis of implementing AWD (e.g., costs for the field water tube, labor, etc.) would provide a more comprehensive understanding of the economic feasibility of this method.

Table 3. Effect of AWDI in no of irrigation, water use (mm) and WUE (kg/ha/mm) in Transplanted rice

Year	Area (ha)	AWDI			Conventional		
		No. of Irrigation	Water use (mm)	Water Use efficiency (kg ha^{-1}mm^{-1})	No. of Irrigation	Water use (mm)	Water Use efficiency (kg ha^{-1}mm^{-1})
2019	50	30	935	7.53	39	1368	4.30
2020	80	29	871	6.67	40	1300	4.08
2021	80	22	950	6.22	38	1540	3.42
2022	80	26	891	6.70	42	1369	3.90
2023	36	28	901	6.73	40	1394	3.92
Average		27	910	6.78	39	1394	3.92

4. CONCLUSION

Farmers have reported significant benefits from adopting AWDI. They have observed reduced water consumption, improved crop health and resilience, enhanced soil quality, increased yieldsand overall economic and environmental advantages. Despite initial hesitation, many farmers have found AWDI to be a valuable and effective irrigation technique that has positively impacted their agricultural practices. A five-year study evaluated AWDI's effectiveness in water-saving rice cultivation. Results showed significant reductions in water consumption (up to 49%), fewer irrigations (12 less than traditional methods), and increased yields (7045 kg/ha compared to 5927 kg/ha). AWDI also improved

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water use efficiency and generated higher economic returns. These findings highlight AWDI as a promising technology for sustainable rice production in Tamil Nadu.

Comment [AA24]: the conclusion is strong, it could be enhanced by briefly mentioning any challenges or limitations faced during the implementation of AWDI, such as the need for proper monitoring tools or potential issues with scaling the technology. This would provide a more balanced perspective and help readers understand the practical considerations for wider adoption.
It would also be helpful to emphasize the broader implications of these findings for other regions with similar agricultural conditions, suggesting that AWDI could be a scalable solution for water-scarce areas beyond Tamil Nadu.

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