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Maximization of Productivity and Water Saving through Alternate Wetting and Drying Irrigation (AWDI) in Rice under Tamil Nadu Irrigated Agriculture Modernization Project (TN IAMP) Aliyar Sub Basin Farmers of Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

TN IAMP-II Aliyar sub basin scheme operated by Agricultural College and Research Institute (TNAU), Vazhavachanur, Tiruvannamalai, Tamil Nadu state has conducted large-scale front-line demonstrations on Alternate Wetting and Drying Irrigation (AWDI) practice in transplanted paddy growing in 11 villages of Tiruvannamalai district at 100 farmer's holdings during *kharif* season of 2019-20 and 2020-21. The data on productivity, economics and water saving in demonstrated plots were compared with Flood irrigation 1200 mm (Farmer practice). The demonstrated plot yield was 64.2 q / ha compared with farmer practice (51.7 q / ha). The yield increase was 24.3 per cent. The extension gap, technology gap and technology index were 12.6 q ha^{-1}, 5.8 q ha^{-1} and 8.29 per cent, respectively. The higher gross return (Rs. 128,443 ha^{-1}), higher net return (Rs. 74,319ha^{-1}) and B: C (2.38) was observed in demonstrated plot compared to farmers' practice plot (Flood irrigation). Higher yield and returns due to reduced cost of cultivation, higher grain yield, net returns and more water saving in AWDI (24.7%).Water depth of 5 cm was maintained in the demo plot (T2) over the farmer's practice (T1) (Water depth 30.0 cm) and the field water level was measured by Field water Tube. Created awareness and motivated the farmers to adopt AWDI practices in TN IAMP Phase II Aliyar sub basin of Tiruvannamalai district.

Keywords: TNIAMP; paddy; field water tube; water saving; economics.

1. INTRODUCTION

"Rice (*Oryza sativa* L.) is a major staple crop with more than 50 kg of rice being consumed per capita per year worldwide, and globally, over 478 million tons of milled rice was produced in 2014-15 of which over 90% was used directly for human consumption" [1,2]. "India is producing 22.1 per cent of it (105 million tonnes of rice), in an area of 44 million hectares" [3]. The depletion of surface and subsurface water resources has been made water a limiting factor in rice production. [4]. Estimate by IRRI, Philippines, 2009 says that rice is being one of the least water use efficient crops which needs about 5000 liters of water for producing 1 kg of un milled rice. The traditional water management *viz*., continuous flooding system makes the paddy production as a less efficient in water uptake.

When paddy crops are grown, the Alternate Wetting and Drying Irrigation (AWDI) method can increase crop yields while saving a significant amount of water. This method can cut the amount of water used for irrigation by 35% per hectare on average. [5]. Rice plays a cruciall role in guaranteeing global food security, but traditional rice cultivation, which involves growing rice in flooded paddy soils, requires more water when comparing with other cereal crops. The growing concern of water scarcity, which presently affects approximately 4 billion people worldwide, highlights the need to establish sustainable agricultural practises that can decrease water consumption while preserving or enhancing crop yields to sustain a burgeoning population. The growing concern of water scarcity, which presently affects approximately 4 billion people worldwide, highlights the urgent need to establish sustainable agricultural practises that can decrease water consumption while preserving or enhancing crop yields to sustain a burgeoning population [6,7]. "Alternate Wetting and Drying (AWD) is an irrigation management technique that has been demonstrated to lower water consumption in rice systems". [8]. "Fields are exposed to intermittent flooding under AWDI, which alternates cycles of saturated and unsaturated conditions. Irrigation is stopped and water is let to evaporate until the soil reaches a predetermined moisture content, at which point the field is flooded again. When compared to continuously flooded rice system it has been reported that AWDI can cut water inputs by 23%". [9]. "According the recent estimates it is predicted that there would be acute water shortage in the coming decade which urges need to develop an alternative system of rice cultivation to save the water and other inputs. AWD is a water conservation technique that can be utilized by farmers to minimize their rice field irrigation water usage while maintaining crop yield and it is an irrigation technique that reduces water inputs in rice without sacrificing rice yield by introducing unsaturated soil conditions during the growing season" [10,11]. "According to Tuong, it was recorded the successful usage of field water tube in AWDI management regime for water depth monitoring and capable to indicate the right time to irrigate crops and saved water, without incurring any yield penalty and using of field water tube in AWDI was very safe to restrict the water use to 25 per cent was reported by Suresh Kulkarni" [12,13].

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 idenfied 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.

2. MATERIALS AND METHODS

Tamil Nadu Irrigated Agriculture Modernization Project (TNIAMP) Phase-II, Aliyar sub basin by Agricultural College and Research Institute, Vazhavachanur, Tiruvannamalai was conducted large scale frontline demonstrations in irrigated lowlands and followed AWD practices by using field water tube for two consecutive years during *kharif* seasons of 2019-20 and 2020-21 at farmer's fields of Agarampallipattu, Thenmudiyanur, Radhapuram, Sathanur, Nedungavadi, Kanakkandal, Veeranam villages of Thandrampet block and Vinnavanur, Kannagurukai, Uchimalaikuppam villages of Chengam block of Tiruvannamalai district. There were two treatments T1: Farmers practice (Continues ponding of water at 5 cm depth) and T2: AWDI (irrigation water was applied when water level has dropped to about 5 cm below the surface of the soil). Monitoring the water depth (measured by a "pani pipe") on the field with a "field water tube" is a useful and safe method of implementing AWDI. The water depth will gradually drop after irrigation. Irrigation was applied to re-flood the field to a depth of approximately 5 cm after the water level dropped to about 5 cm (measured by Field water tube) below the surface of the soil. The field was kept flooded from one week after transplanting to the week before flowering and during flowering, topping up to a depth of 5 cm as needed. The water level was kept at 5 cm from the time of flowering to ripening.

A field tube in flooded field: The field water tube was constructed from 30 cm of 10"–15 cm plastic pipe, which allowed for easy soil removal and easy visibility of the water table. Make numerous holes in the tube spaced two centimeters apart on all sides to allow water to easily enter and exit the tube. The tube was driven into the ground until it protrudes 15 cm above the soil's surface. The tube's bottom was then visible after the soil inside was removed. A few weeks (one and a half) 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 herbicide.. During this study, fertiliser recommendations for flooded rice were strictly adhered to. Before irrigation, N was applied to the dry soil, and the entire package of practices was carried out in accordance with the guidelines provided by the Tamil Nadu Agricultural University.

The large-scale demonstration was conducted in order to investigate the technology gap between the potential yield and demonstrated yield, the extension gap between demonstrated yield and yield under current practice, and the technology index. By using a random crop cutting technique, the yield data were gathered from the farmers' practices and the demonstration. Qualitative data was then transformed into quantitative form and expressed as a percentage increase in yield. [14]. Following additional data analysis with basic statistical tools, the technological index, technological gap, and extension gap were computed [15] as given below.

Technology gap= Potential yield - Demonstrated yield

Extension gap = Demonstrated yield - Yield under existing practice

$$\text{Technology index} = \frac{\text{Potential yield} - \text{Demonstrated yield}}{\text{Potential yield}} \times 100$$

3. RESULTS AND DISCUSSION

3.1 Grain Yield

The supervision of the Agricultural College and Research Institute, Vazhavachanur,

Table 1. Productivity, Extension gap, Technology gap and Technology index of paddy as grown under large scale AWDI demonstration and existing package of practices

Year	Area (ha)	No. of farmer's	Potential yield (q ha^{-1})	Average Yield (q ha^{-1})		% increase over FP	Extension gap (q ha^{-1})	Technology gap (q ha^{-1})	Technology index (%)
				AWDI	FP				
2019-20	40	40	70.0	64.5	51.8	24.5	12.7	5.5	7.86
2020-21	60	60	70.0	63.9	51.5	24.0	12.4	6.1	8.71
Total/Mean	**100**	**100**	**70.0**	**64.2**	**51.7**	**24.3**	**12.6**	**5.80**	**8.29**

Table 2. Economic analysis of Alternate Wetting and Drying Irrigation (AWDI) and farmer practices of paddy as grown under large scale cluster demonstration under TN IAMP-II Aliyar sub basin of Tiruvannamalai District

Year	Cost of cultivation (Rs./ha)		Gross Return(Rs./ha)		Net Return(Rs./ha)		Benefit Cost Ratio		No. ofIrrigation(No.)		Irrigation water saved (%)
	AWDI	FP	AWDI	FP	AWDI	FP	AWDI	FP	AWDI	FP	
2019-20	54078	52274	129001	103771	74923	51497	2.39	1.98	21	25	20.0
2020-21	54171	52285	127885	103116	73714	50831	2.36	1.97	20	26	29.4
Average	**54125**	**52280**	**128443**	**103444**	**74319**	**51164**	**2.38**	**1.98**	**20.5**	**25.5**	**24.7**

Tiruvannamalai TNIAMP Phase II Aliyar sub basin scientist crop yield was harvested accordingly. The rice yield from both the plots i.e., demonstration and farmers' practices were compared and it evidently shows that an average yield of demonstrated plots was 24.3 per cent higher than that of farmer's practices (Table 1). The rice grain yield under demonstrated plots were 64.5 and 63.9 q ha^{-1} with an average of 64.2 q ha^{-1} from the year 2019-20 and 2020-21, respectively. However, it was 51.8 and 51.5 q ha-1 with an average of 51.7 q ha^{-1} under farmer's practice. The reasons behind the increase of yield under demonstrated plots might be due to AWD improves the aeration in the root zone, their by increased number of tillers per metersquare and which increased the yield. Santheepan and Ramanathan (2016) also reported similar results.

3.2 Extension Gap

A calculation was made to determine the extension gap between farmers' practices and demonstrated technology. The average result was 12.6 q ha-1. (Table 2) and the potential yield of India is 70 q/ha. This discrepancy might be attributed to the adoption of AWD technology in demonstrated plots which resulted in higher grain yield than the farmer's practices. On the basis of the extension gap, the farmers were incentivized to implement the alternative wetting and drying approach in order to mitigate the extension gap and enhance their yield. Our results share a number of similarities with Raju et al. [16] findings.

3.3 Technology Gap

The technology gap was calculated by deducting the demonstrated plot yield from the potential yield of the paddy crop. The recorded technology gap was 5.5 and 6.1 q ha^{-1} during 2019-20 and 2020-21 respectively and the average technology gap was found 5.8 q ha^{-1}. A higher technology index was indicative of both insufficient extension services and insufficiently tested technology to be transferred to farmers.

3.4 Economic Analysis

The demonstrated technology was observed that the higher gross return (Rs. 128443 ha-1), higher net return (Rs. 74319 ha^{-1}) and higher benefit cost ratio (2.38) on overage of both the years as compared to farmers practices (Table 2 Greater yield led to higher net returns, which may have been the consequence of sound management techniques. This is in good agreement with Daniela et al. [17] findings.

3.5 Water Saving through AWD

The demonstrated technology was observed less number of irrigation (20.5) and average per cent of water saving (24.7%) to complete the life cycle of paddy as compared to farmer's practices.

3.6 Farmer's Feedback

Number of irrigations was reduced by AWDI through Pani Pipe technology will increase the production area thereby, more number of tillers were produced in rice which leads to higher yield, less pest and disease incidence. Pani Pipe will be easily manufactured by farmers themselves, simple method to follow meanwhile it will reduce the cost per acre.

4. CONCLUSION

Alternate Wetting and Drying Irrigation is a promising management practice through Pani Pipe with respect to judicious application of irrigation water, maximize the yield of paddy and besides higher water saving per cent for the benefit of TN IAMP-II Aliyar sub basin farmers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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