Agronomy ICAR-IIRR Technology 3:

Indian Council of Agriculture

Proforma for Certifying a Technology

IoT enabled AWD irrigation system for reducing GHG emissions and enhancing sustainability of rice production

Submitted by

ICAR-Indian Institute of Rice Research
Rajendranagar, Hyderabad-500030, India

Certifying Products/Technologies/Process/Methodology/Model/Protocol/Policy etc.

Item	
1. Name of the product/technology (as defined above)	IoT enabled AWD irrigation system for reducing GHG emissions and enhancing sustainability of rice production
2. Name and address of the Institute	ICAR-Indian Institute of Rice Research, Rajendranagar, Hyderabad – 500030, Telangana
3. Institution(s) responsible for developing/evaluating/identifying including collaborators, if any	ICAR-IIRR & Farms2Fork Technologies Pvt Ltd, (CultYvate), #783, 33rd A cross, 9th Main, Jayanagar 4th Block, Bangalore – 560 011
4. Source of product/technology (Research Project/Student Research/Any other ad-hoc research study)	Research Project
5. Period of development/evaluation/validation	2021-2023
6. Developers (Lead and Associates)	Dr. R. Mahender Kumar
7. Summary of the product/technology (maximum of 200 words)	India occupies 1 st position in the area and 2 nd position in production after China in the world According to FAO report, global rice requirement by 2025 will be 800 m t. At the moment, rice production is less than 600 m t and needs additional 200 m t. which has to be produced by increasing productivity per unit area against the diminishing resources (However, the findings at IIRR suggest that, by judicious water management, the area under rice can be doubled The findings revealed that, in view of global warming, the automated irrigation sensors, irrigation devices and GHG sensors (CH_4, N_2O & CO_2) controlled/reduced the use of electricity and water to ensure the sustainable productivity, improved irrigation efficiency and further reduced the greenhouse gas emissions.
8. Is it a new technology? (Yes/No). If no, prove the details of the technology modified	Yes
9. IPR involved, if any (Patent/Copyright/Industrial Design Registration/Variety/Germpl	Nil Patent Granted.

asm registration). Provide Filed/Granted number	
10. Validation procedure followed (within Institute, collaborators, multilocation/multi-site testing)	Validation is followed strictly at IIRR as well as farmers' fields in different states
11. Brief description of research output/technology	• **Water input management and reduction in irrigated rice** • **Already tested in farmers fields with very good results** • **Useful for claiming carbon credits for rice cultivation**
a. Objective of the product/technology	• Promote sustainable rice production by optimizing water use and reducing greenhouse gas emissions. • - Enhance irrigation efficiency through IoT-enabled AWD systems. • - Increase farmer income via carbon credit programs and reduced input costs. • - Align with SDGs (Goal 2: Zero Hunger, Goal 6: Clean Water, Goal 12: Responsible Consumption).
b. Detailed methodology of the proposed product/technology	The portable AWD (Alternate Wetting and Drying) sensor is a compact, easy-to-use device designed to improve water use efficiency in paddy cultivation. Its portability allows it to be rotated across multiple fields, making it ideal for smallholder farmers or shared deployment by agri-entrepreneurs. A single Bluetooth-enabled sensor can be assigned to one field officer, who can collect data from approximately 250 farmers with precise date, time, location, and 100% accurate water level readings. This data is automatically transmitted to the cloud without any manual intervention. Based on these readings, the system autonomously sends SMS alerts or initiates voice calls to farmers advising them to start or stop irrigation. Simultaneously, it also notifies field officers to schedule timely visits, ensuring efficient data collection and actionable irrigation advisory. AI and ML analyze data for precision irrigation, reducing water use by up to 40%. Field officers train farmers, validate data, and ensure device maintenance across clusters.

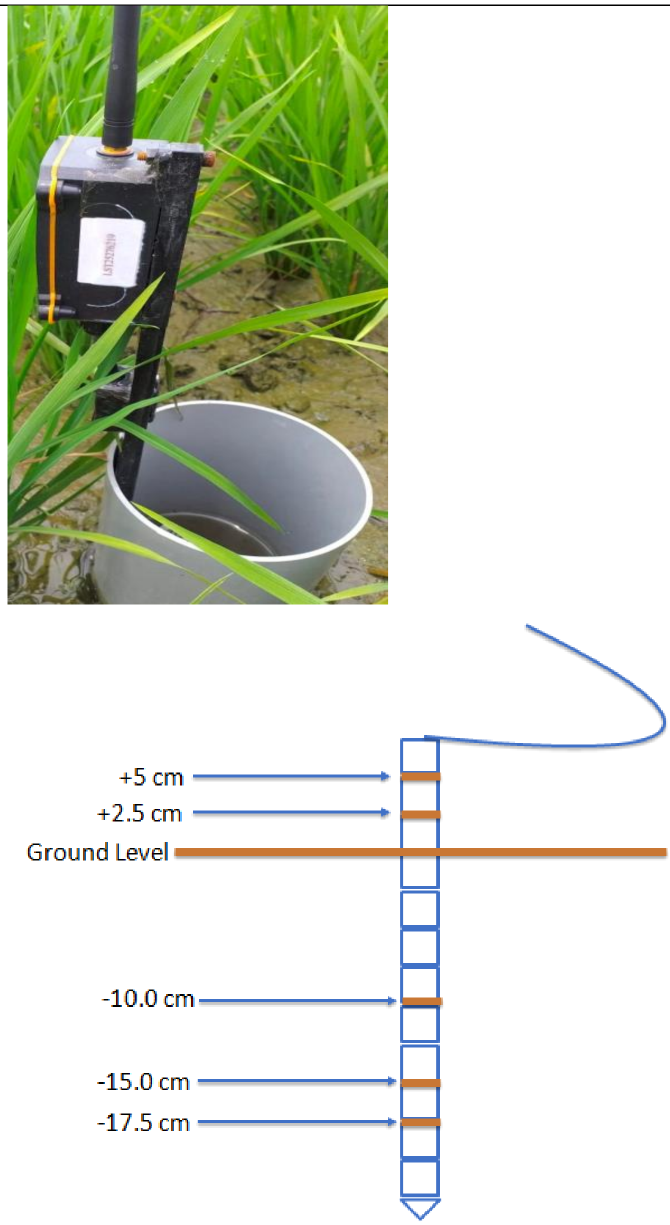


Fig. 2. Sensor probe used for measuring water level in the paddy field.

Fig. 3. Digital water meter used for quantifying the applied irrigation water

c.Yield/productivity gain	• IoT based water management of 5 cm depletion of water gave on par yields (6.12 t/ha) of flooded rice (6.42 t/ha). • Among the various sensor irrigation regimes, flooded water management or AWD at 5 cm depletion of irrigated water were found to be economically best with higher grain yield, net returns and B:C ratio (2.7) with reduced water application. • With respect to various irrigation regimes, higher water use efficiency and water productivity were recorded with AWD at 5 cm depletion and water saving to the extent of 16-28%. Interaction effect of establishment methods and • Among the irrigation regimes, AWD at 5 cm depletion (I1) sensor based is the best treatment in terms of gross energy output, water use efficiency and water productivity.
d. Saving of water, labour, time and energy	Water to the tune of 28% Energy: AWD with IoT 181**(GJ ha^{-1}) over Flooded 178 (GJ ha^{-1})** Saves 25 – 30% water (30-40) lakh liters of water per hectare per season. Reduces electricity costs by 30% (₹3,600/acre savings to government), fungicide use by 20-30%, and labor through well planned monitoring and advisories.
conservation of soil	AWD reduces waterlogging, preserving soil structure and reducing methane emissions by 60% (1200-12000 tons GHG reduction annually). Promotes sustainable soil health by minimizing chemical inputs.
f. Capacity	Started with 50 acres in 2019 and have covered close to 17,000 acres in 2024
g. Efficiency	Achieves 95% precision in water level monitoring. Reduces irrigation cycles, optimizing resource use.
h.Cost effectiveness including B:C ratio	B; C ratio : 2.70
i. Uniqueness of the technology in comparison to existing ones	The uniqueness of the portable AWD sensor technology lies in its seamless integration of precision, scalability, and automation in a low-cost, farmer-friendly solution. Unlike traditional systems that rely on manual observation or expensive fixed infrastructure, this innovation leverages Bluetooth connectivity, cloud integration, and automated communication to deliver real-time, location-specific irrigation guidance. Its ability to collect highly accurate water level data—timestamped and geo-tagged—without any manual input significantly enhances reliability. By enabling a single field officer to

	monitor up to 250 farmers and trigger automated advisories, it transforms irrigation management from reactive to proactive, ensuring water savings, yield stability, and operational efficiency at scale.
j.Passport data of the product/technology	Technology: IoT-enabled BLE driven AWD Sensor. Developer: ICAR-IIRR & cultYvate. Validation: 2021-2023, IIRR and multi-state farmer fields. Application: Paddy cultivation. Patent: granted. Scalability: 500-5000 acres.
12.Details of relevant data generated during the development/validation	Attached
13.Proposed stakeholders	Farmers
14.Commercial potential, if any	The commercial potential of the portable AWD sensor solution is immense, particularly in water-intensive crops like paddy where irrigation inefficiencies are widespread. Paddy, traditionally grown using the flooding method across the globe, significantly contributes to greenhouse gas emissions, accelerates groundwater depletion, and diminishes yield potential—often pushing farmers into financial distress. This solution directly addresses these challenges through data-driven irrigation, enhancing productivity while conserving resources. Its affordability, ease of deployment, and scalability make it highly attractive for government programs, agri-input companies, FPOs, and CSR-driven initiatives focused on sustainable agriculture. A key enabler is the agri-entrepreneurship model, where trained local youth manage the deployment and advisory services, creating rural employment and boosting village-level GDP. Cost will be as low as Rs 400 per farmer for season with saving of 16-28% water, electricity and enhancement of Productivity to 15-20 %.
15.Publications/photos/video clipping, if any	Attached
16. Any other information not covered above	The project aligns with Punjab's groundwater crisis mitigation, targeting over-exploited blocks (e.g., Sangrur, Patiala). Self-sustainable from Year 4 via carbon credits, with farmer training ensuring independent device operation. Supports rural employment by appointing progressive farmers as field officers.

Flooded water management (I4) recorded significantly superior grain yield which was statistically in parity with AWD at 5 cm depletion (I1). Favourable soil water balance maintained with sufficient number of irrigations during the entire crop growth period under flooded water management and AWD at 5 cm depletion helped paddy to produce higher yield attributes since water plays a vital role in the carbohydrate metabolism, protein synthesis, cell division, cell enlargement and partitioning of photosynthates to sink that ultimately reflected in the form of higher grain yield. Significantly lower grain yield was recorded with AWD at 15 cm depletion (I3), but at par with AWD at 10 cm depletion (I2).

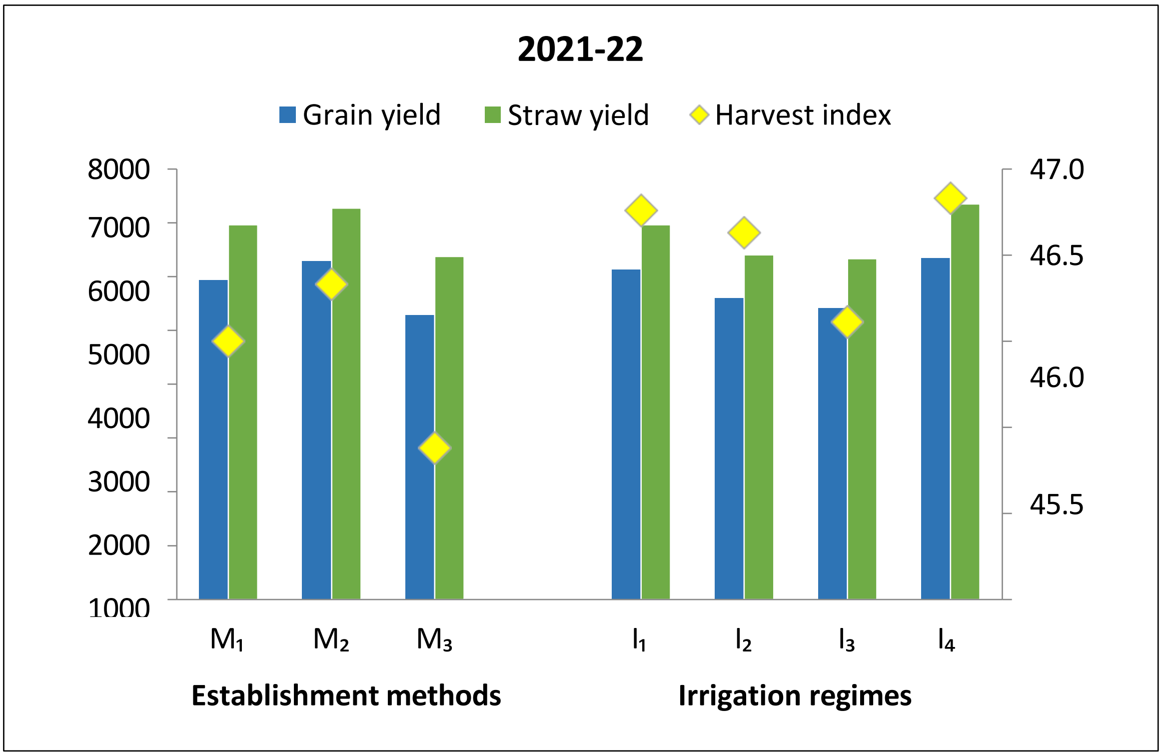
With regard to different irrigation management practices, AWD at 5 cm depletion (I1) recorded higher total water use efficiency, which was significantly superior over all other irrigation regimes. Next highest total water use efficiency was registered with AWD at 10 cm depletion (I2), which was at par with AWD at 15 cm depletion (I3). Reduction in consumptive use of water coupled with optimum yield might increase the total water use efficiency in AWD irrigation regimes. These results corroborate with the findings of Hussain et al. (2021).

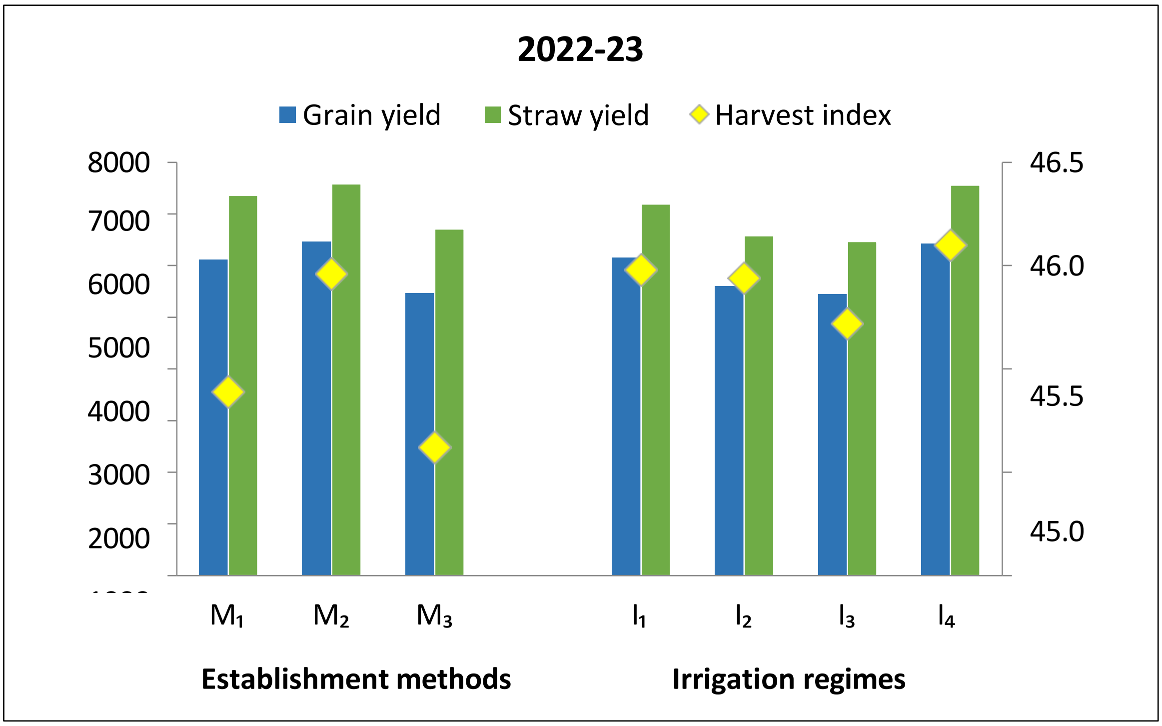
Flooded water management (I4) registered significantly lower total water use efficiency over all other irrigation regimes. Major portion of water applied through flooded water management is wasted in the form of percolation and evaporation losses resulting in lower total water use efficiency.

Water productivity recorded with AWD at 5 cm depletion (I1) was significantly superior over all other irrigation regimes.

Table 4.11. Grain and straw yield (kg ha^{-1}) and harvest index (%) of rice as influenced by establishment methods and sensor based irrigation regimes

Treatments	Grain yield			Straw yield			Harvest index		
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled
Establishment methods (M)									
M_1 - Normal transplanting	5930	6121	6029	6961	7359	7160	46.0	45.4	45.7
M_2 - Mechanized SRI	6285	6459	6375	7269	7582	7426	46.3	46.0	46.1
M_3 - Wet DSR	5278	5463	5374	6375	6706	6640	45.4	45.1	45.3
SEm ±	133.9	133.0	94.2	127.6	151.1	105.0	0.64	0.76	0.25
CD (P = 0.05)	526	522	370	501	593	412	NS	NS	NS
Sensor based irrigation regimes (I)									
I_1 - AWD at 5 cm depletion	6132	6148	6141	6960	7191	7076	46.8	46.0	46.4
I_2 - AWD at 10 cm depletion	5596	5599	5595	6404	6579	6493	46.6	45.9	46.3
I_3 - AWD at 15 cm depletion	5419	5449	5444	6334	6468	6412	46.1	45.7	45.9
I_4 - Flooded water management	6343	6423	6389	7349	7558	7168	46.8	46.1	47.1
SEm ±	168.4	158.8	123.0	183.1	153.1	108.3	1.11	0.60	0.67
CD (P = 0.05)	500	472	366	544	455	322	NS	NS	NS
Interaction									
M at I									
SEm ±	291.6	275.1	213.1	317.1	265.3	187.6	1.48	1.34	1.08
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
I at M									
SEm ±	285.9	272.9	186.8	302.8	275.0	193.4	1.33	1.21	0.96
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

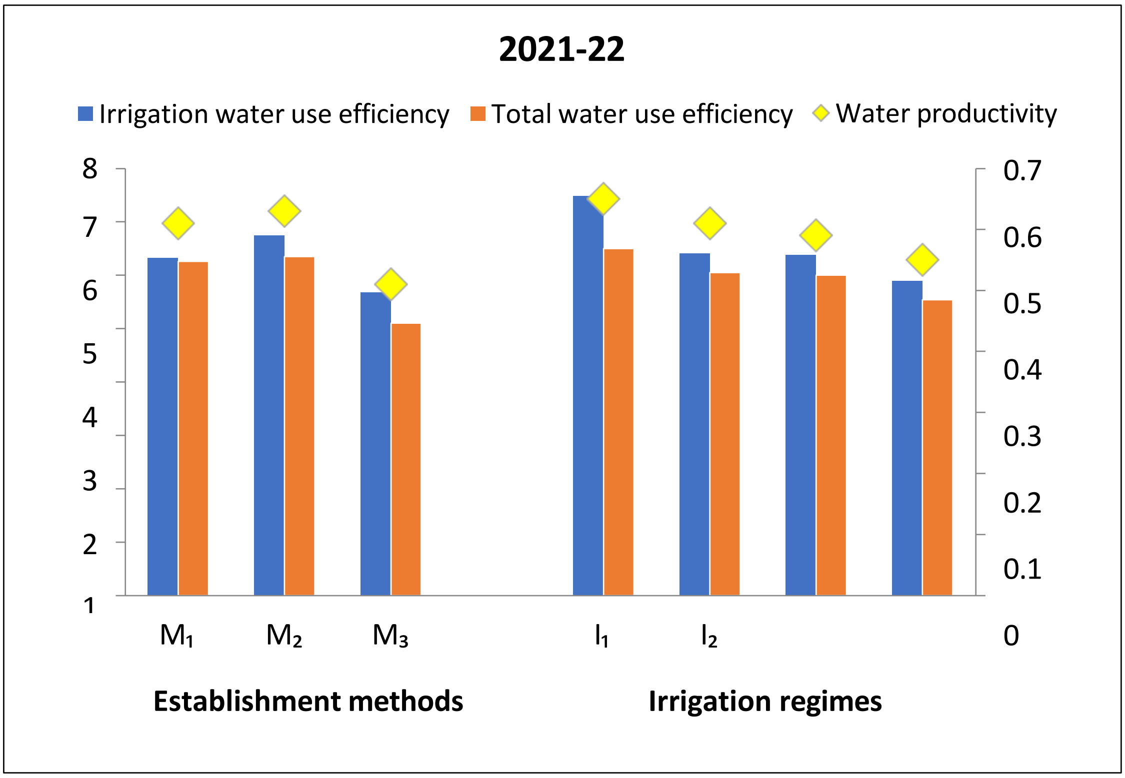


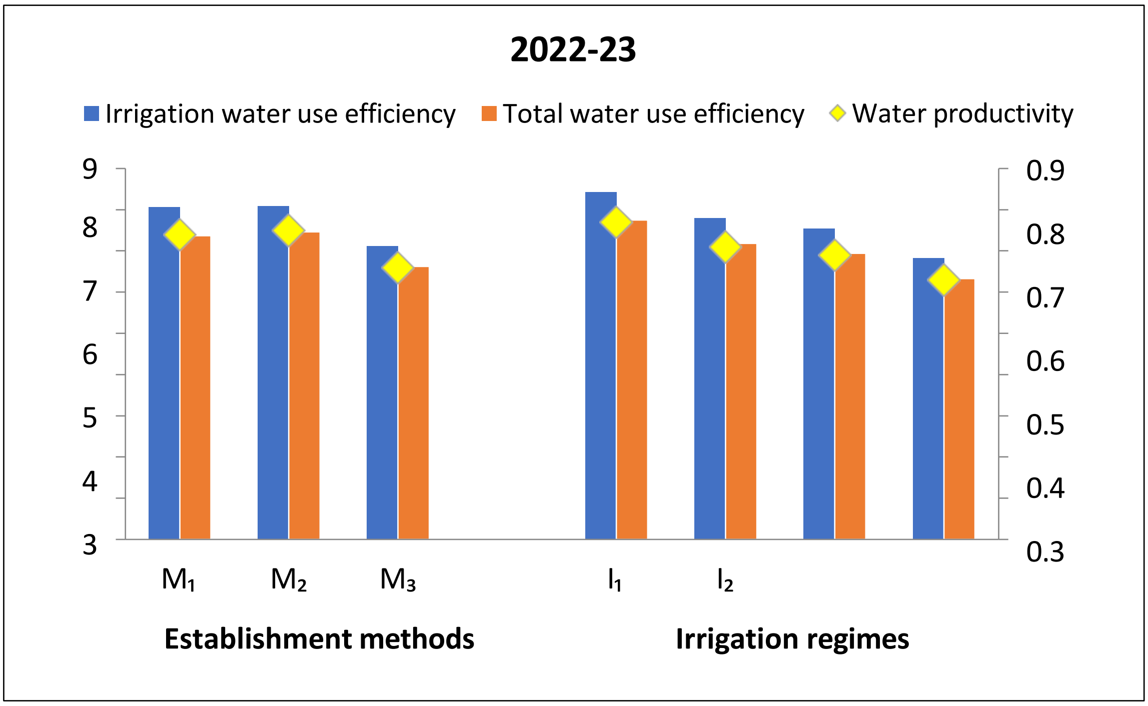


Grain and straw yield (kg ha-1) and harvest index (%) of rice as influenced by establishment methods and sensor based irrigation regimes.

Table 4.13. Water use efficiency (kg ha-mm^{-1}) and water productivity (kg m^{-3}) of rice as influenced by establishment methods and sensor based irrigation regimes

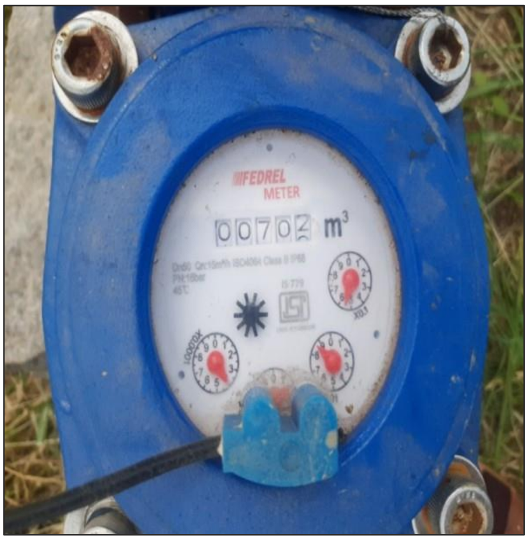
Treatments	Irrigation water use efficiency			Total water use efficiency			Water productivity			Water saving (%)
	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	2021-22	2022-23	Pooled	
Establishment methods (M)										
M_1 - Normal transplanting	6.32	8.06	7.16	6.26	7.37	6.56	0.61	0.74	0.66	8.8
M_2 - Mechanized SRI	6.74	8.09	7.42	6.35	7.46	6.78	0.63	0.75	0.68	13.9
M_3 - Wet DSR	5.67	7.12	6.49	5.10	6.62	6.23	0.51	0.66	0.62	-
SEm ±	0.119	0.090	0.110	0.078	0.089	0.087	0.008	0.009	0.009	-
CD (P = 0.05)	0.48	0.39	0.43	0.32	0.36	0.34	0.03	0.04	0.03	-
Sensor based irrigation regimes (I)										
I_1 - AWD at 5 cm depletion	7.48	8.42	7.90	6.50	7.75	7.12	0.65	0.77	0.69	16.1
I_2 - AWD at 10 cm depletion	6.41	7.79	7.13	6.05	7.18	6.64	0.61	0.71	0.66	22.4
I_3 - AWD at 15 cm depletion	6.38	7.54	6.98	6.00	6.94	6.50	0.59	0.69	0.65	28.8
I_4 - Flooded water management	5.89	6.82	6.43	5.54	6.33	6.13	0.55	0.63	0.61	-
SEm ±	0.132	0.179	0.110	0.109	0.172	0.101	0.011	0.020	0.010	-
CD (P = 0.05)	0.37	0.55	0.33	0.33	0.50	0.30	0.03	0.05	0.03	-
Interaction										
M at I										
SEm ±	0.21	0.32	0.19	0.19	0.29	0.18	0.019	0.029	0.018	
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	
I at M										
SEm ±	0.22	0.29	0.20	0.18	0.27	0.17	0.018	0.027	0017	
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	





Water use efficiency (kg ha-mm^{-1}) and water productivity (kg m^{-3}) of rice as influenced by establishment methods and sensor-based irrigation regimes.

Plate . Google map of the experimental field.



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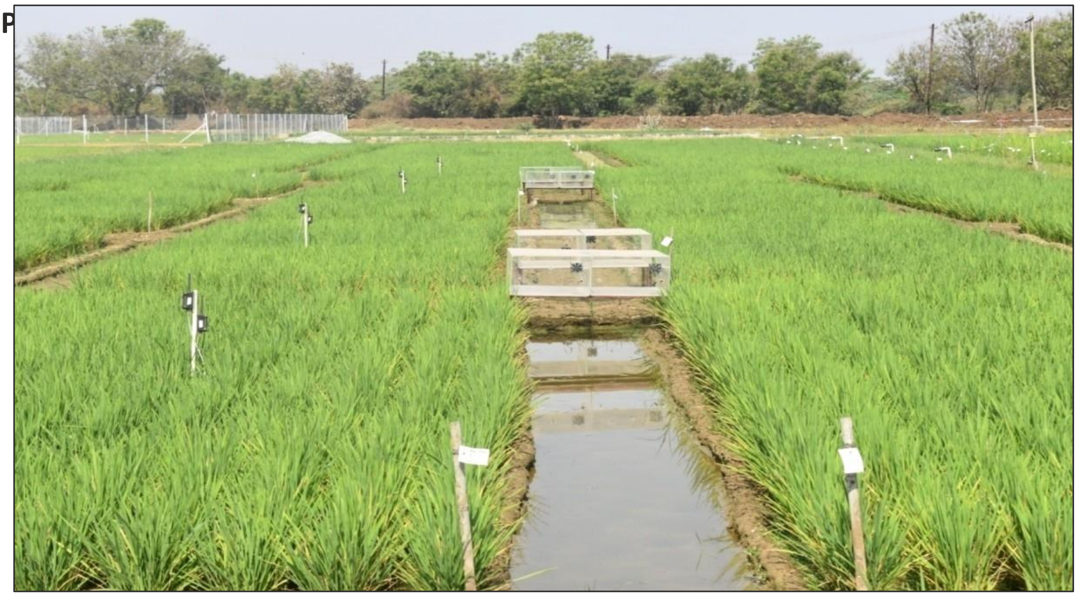

Plate . IoT water meters, water level Sensors installed in the experimental field.

Publication:

A Suryakala, G Karuna Sagar, R Mahender Kumar, G Pratibha, V Umamahesh and B Ramana Murthy. Impact of irrigation regimes on weed dynamics in various rice establishment methods. J Pharmacogn Phytochem 2023;12(5):27-30. DOI: 10.22271/phyto.2023.v12.i5a.14711.

Akshay, DVS, R.M.Kumar, S.Prathibha Sree , B.Sreedevi, MBB Babu and A.S.Sakhare 2024. Optimising growth in Aerobic rice through IoT based Drip Irrigation Fertigation" International Journal of Plant and Soil science 36(70 : 190-200

- Among the various sensor-based irrigation regimes, flooded water management or alternate wetting and drying at 5 cm depletion of irrigated water were found to be economically feasible with higher grain yield, net returns and B:C ratio.
- Among the various sensor-based irrigation regimes, higher water use efficiency and water productivity were recorded with alternate wetting and drying at 5 cm depletion of irrigation water. Interaction effect of establishment methods and sensor-based irrigation regimes was found to be non-significant during both the years of study as well as in the pooled mean.

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Impact of irrigation regimes on weed dynamics in various rice establishment methods

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DOI: https://doi.org/10.22271/phyto.2023.v12.i5a.14711

Abstract
A field experiment conducted at IIRR, Hyderabad with three crop establishment methods (normal transplanted rice, mechanized SRI and wet DSR) as main plot treatments and sensor based irrigation management practices (alternate wetting and drying with 5, 10, 15 cm depletion of water level below the soil surface and continuous flooding) as subplot treatments in split plot design on clay loam soil. Significantly least weed abundance was observed in normal transplanted rice and with mechanized SRI with continuous flooding irrigated conditions during *rabi* seasons of 2021 and 2022. Wet direct seeded rice exhibited severe weed infestation (significantly high weed density and weed drymatter) under alternate wetting and drying conditions compared to mechanized SRI and normal transplanting method.

Keywords: Irrigation regimes, establishment methods of rice, weed dynamics

Introduction

For over one-third of the world's population, rice serves as the main source of calories each day (Ullah and Datta, 2018) [12]. Rice (*Oryza sativa* L.) and it is the second most important staple food crop of world and prime staple food crop of India. It occupied an area of 44.16 million hectares with an annual production of 120.32 million tonnes with a productivity of 2.64 t ha^{-1} whereas in Andhra Pradesh it is cultivated over an area of 2.21 million hectares with a production of 8.32 million tonnes with a productivity of 3.73 t ha^{-1}. Therefore, sustaining and improving the production potential of rice is essential for global food security. In India, rice is mainly cultivated by normal transplanting method. Puddling is done to reduce water infiltration and to maintain the continuous submerged conditions in the field, which helps in weed management and facilitates easier transplanting (Sharma and De Datta, 1986) [11]. The traditional method of transplanted rice cultivation with continual flooding leads to water wastage because of seepage and percolation due to the high hydrostatic pressure of stagnated water and demands the usage of more water, labour and energy, which raises the cost of cultivation. It causes numerous nitrogen losses (percolation, volatilization, and denitrification) that lower the efficacy of nitrogen utilization thereby reducing fertilizer use efficiency. Additionally, it contributes to 1.5% of the world's methane emissions and hastens environmental degradation. In addition, normal transplanting method of rice production on long run leads to destruction of soil aggregates and reduction in macro pore volume. Hence, the traditional way of lowland rice cultivation can no longer be sustained. In order to achieve stable and increased rice production with less irrigation water, it is essential to replace normal transplanted (NTP) rice with sustainable crop establishment techniques like direct seeded rice (DSR) and mechanized system of rice intensification (SRI). Wet DSR conditions help in lowering the expenditure of rice production through reduction in transplantation costs as it lacks nursery raising and it may be more environmentally sustainable (Farooq *et al*., 2011) [3]. The depth of the water influences the type and density of the weed flora (Kent and Johnson, 2001; Kumar and Latha, 2011) [5, 7]. Hussain *et al.* (2009) [4] found that, in AWD, effective weed management is only possible through herbicide application as weed infestation is closely related with soil moisture content and water level in the rice field. Continuous flooding can significantly reduce grass growth and as water levels drop below 15 cm and beyond, grass growth always increases in rice fields. In light of these facts, the present study was undertaken with the aim to evaluate the alternative crop establishment systems of rice and also to determine the differences in weed flora in addition to the weed density and weed drymatter in different rice crop establishment methods.

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Optimizing Growth and Yield in Aerobic Rice through IoT-based Drip Irrigation and Fertigation

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Authors' contributions

This work was carried out in collaboration among all authors. Author DVSA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RMK, SPS, BS, MBBPB and ASS supervised the research work and modified for corrections if any. All authors read and approved the final manuscript.

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Declaration: I/we hereby undertake that the above information is correct. All scientists in the development of this research output have been included in the list of associates. The research output does not involve any third party IPR.

1. Name and signature of all the developers

Name	**Developer / co-developer / Collaborator**	**Signature**
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Dr. B.Sreedevi	Co-developer	
Dr. Mangaldeep Tuti	Co-developer	
Dr. S. Vijaya Kumar	Co-developer	
Dr. K. Surekha	Co-developer	
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Dr. Ch. Padmavathi	Co-developer	
Dr. Senguttuvelu	Co-developer	

2. Recommendations of the Head of Division

3. Recommendations of ITMC/PME

4. Recommendations o DIRECTOR

5. Recommendations of SMD