

## Smart water technique for rice

### Key fact

By using a simple water level gauge and implementing smart but simple water management techniques, farmers can reduce water usage in paddy rice by 15-30 per cent without compromising yields.

### Summary

Traditionally, rice is grown in continuously flooded fields but water for agriculture is becoming increasingly scarce. Scientists have estimated that by 2025, 15-20 million hectares of irrigated rice will suffer some degree of water scarcity. Aware of the precarious state of water resources, the Irrigated Rice Research Consortium (IRRC) has worked to explore, develop and promote strategies and technologies for farmers to help them improve water management and boost yields.



**Under AWD water requirements are reduced by up to 30% with no loss of yield**

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Established in 1997, IRRC provides a framework for partnership between the International Rice Research Institute (IRRI), national agricultural research and extension systems and the private sector in 11 Asian countries. Working together, Consortium members developed a technique known as 'alternate wetting and drying' (AWD). By implementing a cycle of alternate low-level flooding and periods when the soil is allowed to dry out, water requirements can be reduced by up to 30 per cent, with no yield reduction. To enable farmers to avoid over-drying the soil and determine when re-flooding is required, a simple 'level gauge' - PaniPipe - was devised, eliminating the need for complex tables or charts. IRRI is researching the potential of AWD to reduce methane emissions from paddy fields.

### Facts & figures

- A PaniPipe is a 40cm length of 15cm diameter plastic pipe or bamboo, with drilled holes, which is sunk into the rice field until 20cm protrudes above soil level.
- When the water level inside the PaniPipe drops to 15cm below ground level, the field is ready to be re-flooded. This threshold is called 'safe AWD' as it does not impact on yield.
- By using PaniPipes and implementing the smart but simple AWD technique, farmers save up to 30% of the nearly 5,000 litres of water commonly used to produce 1kg of unmilled rice.
- The savings in water has increased farmers' income by more than 30%; often from a net loss to a net gain.
- In Vietnam and Bangladesh farmers reported yield increases of more than 10%.
- In the Philippines, more than 100,000 farmers have adopted AWD, which has also reduced conflicts over water in shared canal irrigation systems.
- In Bangladesh, trials have shown reductions in water consumption of 15-30%, translating into a reduction in pumping costs and fuel consumption and an increased income of US\$67-97 per hectare.

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## Project milestones

- 1970-1980: Trials on non-flooded rice occur at an IRRI farm in the Philippines.
- 1980-1990: Field experiments on non-flooded rice with partners in the Philippines.
- 1990-2000: In-depth scientific investigation to identify thresholds for reducing water use without compromising rice yield carried out in China and the Philippines.
- 2000-2005: The concept of 'safe AWD' is developed. The water tube (PaniPipe) is devised for ease of implementing safe AWD. Farmer-participatory on-farm trials in pump irrigation systems are conducted in the Philippines with research, training and extension partners, along with training and development of extension materials.
- 2005-2010: Dissemination of AWD in gravity irrigation systems. Background research on AWD beyond the safe AWD/no yield penalty and on greenhouse gas emissions begin at IRRI. Safe AWD is widely promoted in the Philippines, Vietnam and Bangladesh. Training and extension activities begin in Myanmar, Indonesia and Lao PDR.
- 2010-2012: Safe AWD is extended with residue and nutrient management to reduce methane emissions. AWD is fully mainstreamed in extension efforts by formal extension institutes, NGOs and civil society organisations in Southeast Asia. Training and extension materials on AWD are included in curricula of agricultural colleges, universities and extension certification schemes.

## Costs and benefits

Studies have shown that as much as 30 per cent less water is needed for AWD without reducing rice yields, increasing farmers' incomes by 30 per cent. In Vietnam, AWD has resulted in a 15 per cent yield increase because of a reduction in lodging. Trials in Bangladesh have shown reductions in water consumption of 15-30 per cent, translating into a reduction in pumping costs and fuel consumption and an increased income of US\$67-97 per hectare. Preliminary research has revealed a reduction of 30-70 per cent of methane emissions depending on the combination of water usage and management of rice stubble.

A 2012 IRRI study revealed that in the Philippines, as a result of AWD, water is more evenly distributed, more fields are reached by irrigation water, particularly for farmers downstream and an increase in 0.5 hectare per farmer was observed. AWD also had a significant effect on farmer's net income representing an increase of US\$86 per hectare. The increase in income was due to the increase in yield for farmers downstream and higher farm gate price of unhusked rice. Labour used on manual weeding and handpicking of snails decreased after AWD implementation. Knowledge and perception of farmers about irrigation also improved, with 80 per cent adopting strategies to save water and cope with the diminishing supply. More farmers were also able to prepare their land synchronously with other neighbouring farms, helping to prevent attacks by insects and other pests.

## More information

International Rice Research Institute - [www.irri.org](http://www.irri.org)

## Smart water technique for rice

Worldwide, water for agriculture is becoming increasingly scarce. Aware of the precarious state water resources, the Irrigated Rice Research Consortium (IRRC) has worked to develop strategies which farmers can adopt to help them improve their water management and productivity. Received wisdom has long been that the more water applied, the higher the yield of rice. But research from the International Rice Research Institute (IRRI) and widespread farmer experience has proved that this is not the case: yields comparable to continuously flooded rice can be achieved with significantly less water using a technique known as 'alternate wetting and drying' (AWD), or controlled irrigation.



**Water for agriculture is becoming increasingly scarce**  
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Worldwide, there are an estimated 150 million hectares of rice, 50 per cent of which is irrigated. Traditionally, rice is grown in continuously flooded fields where almost half of the applied water is lost in percolation and seepage. Scientists have estimated that by 2025, 15-20 million hectares of irrigated rice will suffer some degree of water scarcity. At the same time, each hectare of land used to grow rice will have to provide for at least 43 people by 2050, compared to 27 currently.

Established in 1997, IRRC provides a framework for partnership between IRRI, national agricultural research and extension systems (NARES) and the private sector in 11 Asian countries. IRRC's aim is to develop and validate simple tools for farmers that enable them to address and manage complex problems, such as water scarcity, and reduce the environmental footprint of rice production.

Work on AWD began about a decade ago when scientists from IRRI and the Philippines Rice Research Institute (PhilRice) determined that rice needed to be flooded to a depth of only 3-5cm instead of the more usual 10cm. Moreover, flooding does not have to be continuous and the soil surface can be left to dry out before re-flooding. The cycle of alternate low-level flooding and drying can also be repeated throughout the growth of the crop, although flowering is a critical period when the soil must be flooded.

As much as 30 per cent less water is needed for AWD and no other significant changes to crop management are required, except to ensure that fields are accurately levelled to avoid 'ponding' (pools of water) in low spots and excessive drying where the ground is high. Levelling also has the added benefit that seed germination and growth are more even and weed growth is more consistently controlled, so yields are enhanced.



**Worldwide, there are an estimated 150 million ha of rice**  
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Initially, AWD was not widely adopted as recommendations of how to implement the technique were rather complicated. Some scientists gave recommendations in terms of the number of days of non-flooded soil,



**Work on AWD began a decade ago**  
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which ranged from one to ten days. Others recommended irrigating when soil water tension in the rootzone reached a threshold value of 10kPa (measure used to express moisture availability in the soil for plant use), but farmers did not have suitable equipment to determine when the threshold was reached.

What farmers needed was a simple tool to help them make decisions on when to irrigate. Through multi-location and multi-season experiments, IRRI scientists found that when field water level receded to 15cm below the soil surface, soil water tension in the rootzone was always less than 10kPa, reflecting that water in the soil is still available for plant use.

To enable farmers to avoid over-drying the soil and determine when re-flooding is required, a simple 'level gauge' - PaniPipe - was devised. A 40cm length of 15cm diameter plastic pipe or bamboo, with drilled holes, is sunk into the rice field until 20cm protrudes above soil level. This enables farmers to monitor the level of water inside the pipe: when the water level inside drops to 15cm below ground level, the field is

ready to be re-flooded. The plastic tube eliminated the need for complex tables or charts that would otherwise be needed to determine when farmers should irrigate, taking into account the soil type and terrain.

The threshold of 15cm is called 'safe AWD' as this will maintain yields as the rice roots are still able to take up water from the saturated soil and the perched water (water that sits temporarily above the semi-impermeable plough layer) in the root zone. The PaniPipe helps farmers see this 'hidden' source of water. After creating confidence that 'safe AWD' does not reduce yield, farmers may experiment by lowering the threshold level for irrigation to 20cm or even deeper. Lowering the threshold will increase the water savings, but some yield loss may occur. Such a penalty may be acceptable when the price of water is high or when water is very scarce.

By using PaniPipes and implementing the smart but simple AWD technique, farmers save up to 30 per cent of the nearly 5,000 litres of water commonly used to produce 1kg of unhusked rice. The savings in water has increased farmers' income by more than 30 per cent, often from a net loss to a net gain. Many farmers who struggled to cover costs are now making a profit while farmers in areas with limited water have been able to continue rice farming. In some cases, farmers have also been able to expand areas where irrigated rice can be grown. A bonus is that harmony has been restored to communities where disputes over access to water had soured relations.



**PaniPipes enable farmers to monitor water levels**  
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In some cases, AWD also increases yields. During the period the soil is not covered, the roots grow faster and deeper because they're looking for water. Better anchorage prevents rice stalks becoming flattened by strong winds (lodging) and rice grains ending up in the mud. In Vietnam and Bangladesh yields have increased by 10-15 per cent.

Through IRRC, NARES researchers and extension agents have been encouraged

to make use of and test AWD research on a large scale, further adapt it with their partners and promote it. As a result, NARES have been the main driving force in disseminating AWD: by 2004, farmers in the Philippines, Vietnam and Bangladesh had begun to adopt the technique following demonstration trials and training courses. Large scale adoption occurred in all three countries after AWD began to be promoted through national policies. AWD adoption soon spread to Myanmar (in 2006), Indonesia (2009) and Lao PDR (2010).

In Bangladesh, the Bangladesh Rice Research Institute (BRRI) was instrumental in promoting AWD to farmers, through a system of local champions. Trials revealed reductions in water consumption of 15-30 per cent, translating into a reduction in pumping costs and fuel consumption and an

“One tonne of rice needs two to three Olympic-sized swimming pools of water. So each time you save 30 per cent on one tonne of rice, you get one Olympic-sized swimming pool of water.”

**Dr Bas Bouman, Director, Global Rice Science Partnership**

increased income of US\$67-97 per hectare. In 2009, the secretary of the Ministry of Agriculture directed the Department of Agriculture Extension (DAE) to upscale AWD nationwide. To date, DAE has trained more than 400 staff members on AWD and established 460 demonstration farms in 25 districts. The NGO Practical Action has also conducted demonstrations with 400 farmers,

while Syngenta-Bangladesh has trained 1,200 employees and promoted AWD to 50,000 farmers using its network of farm advisors. Government organisations, such as the Barind Multipurpose Development Authority, and national NGOs, including RDRS Bangladesh, have also been actively involved in the dissemination.

A highlight of AWD adoption in the Philippines has been the inclusion of AWD in the National Rice Self-Sufficiency Program. By 2012, more than 100,000 farmers had adopted AWD and the aim is for 600,000 farmers to have adopted the technology by 2015. PhilRice and the National Irrigation Administration have also successfully used AWD to improve equity and reduce upstream-downstream conflicts in canal irrigation systems.

In Vietnam, the technology has resulted in a 15 per cent yield increase because of a reduction in lodging. The Department of Plant Protection and the Department of Agriculture and Rural Development in An Giang Province have adopted safe AWD. District extension workers have been trained, demonstration plots have been established and safe AWD has been incorporated into the provincial ‘Five Reductions One Must Do’ programme for farmers.

Rice has a high risk of zinc deficiency, even where the soil is considered to have adequate zinc, because zinc deficiency is induced by long-term soil flooding. Zinc deficiency in rice plants can cause stunting, poor tillering and grain filling, and low yields. In humans, zinc deficiency impairs cognitive development for children and causes growth stunting, impairs the immune system and increases susceptibility to respiratory infections and diarrhoea. AWD promotes higher zinc availability in soil and grains by enabling periodic aeration of the soil, which releases zinc from insoluble forms and makes it available for plant uptake.

IRRI researchers believe that AWD also reduces methane emissions. Rice fields emit a lot of methane under flooded conditions, so it’s logical to assume that under AWD with less flooding, rice will emit less methane. So far, results from experiments have been encouraging: methane



**IRRI researchers believe that AWD reduces methane emissions**  
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emissions have been 30 to 70 per cent lower, depending on the combination of water usage and management of rice stubble. However methane emission varies with soil type so the data needs to be re-assessed for different soils and conditions.

With the prospect of global climate change, resulting in failed monsoons and other seasonal rains, and increasing competition for reduced water supplies from domestic and industrial users, there is a clear and urgent need to find new approaches to rice cultivation in order to sustain yields of this vital food crop on which billions depend.

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## Contact

### Rubenito Lampayan

Water management specialist

International Rice Research Institute

NAFRI Compound

Nongyiengkham Village

Xaythany District

Vientiane Capital

Lao PDR

Tel: +91 112 584 382, ext. 21

Email: [r.lampayan@irri.org](mailto:r.lampayan@irri.org)

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