

Alternate wetting and drying technology for rice production

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Practice of alternate wetting and drying (AWD) technology in rice is a viable option for water saving that has been implemented in various regions of India. However, its effectiveness has been limited due to requirement for more water and inconsistencies in nutrient supply in light textured soil. By adopting such potential water-saving techniques in rice cultivation, not only the crop yield improves, but also carbon sequestration increases, while reducing resource utilization including water, labour, energy and time, and lowering greenhouse gas (GHG) emissions. AWD offers several significant benefits such as utilizing 23–33% less water, enhancing grain quality by reducing arsenic (As) and mercury (Hg) content, reducing GHG emission, improving water efficiency, maintaining or even increasing grain production. Additionally, intermittent irrigation with AWD method has proven successful in reducing disease and insect pest infestations in lowland rice.

Keywords: Methane emission, Rice production, Water saving, Water use efficiency

ALTERNATE wetting and drying (AWD), an irrigation scheduling methodology for rice production is an extensively investigated innovation for adapting agri-food systems to climate change, reducing environmental footprints and ensuring a resilient and sustainable food production system. AWD is a low-cost invention that enables farmers to enhance total farm production efficiency, reduce greenhouse gas (GHG) emissions, and adapt to conditions of rising water shortage (drought). It is viewed as a strategy to develop agri-food systems into ones that are more productive, resilient, biologically diversified and equitable. AWD claims that maintaining food security and strengthening agricultural sector resilience to climate change needs re-thinking and re-imagining in a manner in which the impact of irrigation rice systems utilising AWD can be scaled up.

Methane emissions from rice field in wetlands are contributing to global warming crisis, as methane

traps 25 times more solar energy than carbon dioxide. Source of this methane is due to lack of oxygen in flooded rice fields, leading to anaerobic fermentation of soil organic matter. This results in release of methane into atmosphere through rice plants roots, stems, diffusion and ebullition from buried soil. Wetland rice fields are estimated to emit 20–100 Tg/year of methane, accounting ~29% of all annual human-caused methane emission. AWD is an irrigation scheduling strategy for rice production, is a well-researched innovation to adapt agri-food system to climate change. It minimizes environmental impact, ensures resilient/sustainable food production system. AWD technique reduces water usage by up to 30% and GHG emissions by up to 50%, while still retaining production output. Process of alternating between drying and re-flooding rice field is what makes AWD possible. To successfully implement this method without sacrificing yield, monitoring depth of water in field

using tools such as a “field water tube or pani pipe” is recommended. In AWD, rice fields are irrigated by alternating periods of drying. Using monitoring instruments such as field water tube or pani pipe, farmers can determine when to provide water to their fields. This approach has shown to decrease methane emissions by 48% compared to continuously flooding fields. By combining AWD with precision fertilizer tools, GHG emissions can be reduced. Furthermore, water-saving technology, i.e. drip and sprinkler irrigation can improve water usage efficiency. Duration of flooded and non-flooded interval is determined by various factors, i.e. soil type, weather conditions and crop growth stage.

Key points of AWD

To effectively implement AWD in rice fields, farmers can utilize a field water tube to monitor water level in soil. This tube which can be made of plastic or bamboo and should have a diameter of 10–15 cm, is perforated

with multiple holes to allow for easy flow of water in and out. The tube is then hammered into the soil, with 15 cm protruding above surface, and the inside of tube is cleared of soil to make bottom visible. Water level inside tube should match water level outside of it after field has been irrigated. If water level does not match after a few hours, it is likely that holes are blocked and tube needs to be reinstalled. Field water tube should be placed in an easily accessible and representative area of field close to bund, to make monitoring the water depth simple and efficient. Irrigation should be done when the water level drops to around 15 cm beneath the soil surface, re-flooding the field to a depth of ~5 cm. During period starting a week before flowering to a week after it, the field should remain flooded, and water should be added to reach a depth of 5 cm as required. As grain filling and ripening stage begins, water level can then be reduced to ~15 cm below soil surface before re-flooding with irrigation water. AWD can begin a couple of weeks after transplanting rice seedlings. If there is a high presence of weeds, it's recommended to wait 2–3 weeks to allow pond water to suppress weeds and enhance the effectiveness of herbicides. Same fertilizer recommendations used for flooded rice can be used. It is suggested to apply nitrogen fertilizer directly on dry soil just prior to irrigation.

This cost-effective solution enables farmers to adapt to water scarcity conditions like drought, boost overall production efficiency, and GHG emissions. AWD is considered to transform agriculture and food systems into more sustainable, efficient, biologically diverse and fair forms, fulfilling our obligations. Application of AWD is typically implemented during early stages of rice growth. However, at anthesis and flowering, rice fields must be constantly flooded as the crops are more susceptible to water scarcity at this time. This method is not effective in soil with rapid water drainage, i.e. sandy soil, as it leads to limited water savings.

Effect of AWD on grain yield and water productivity

Regulating irrigation in agriculture can result in a substantial decrease in labour, time, water and cost savings. On average, it is estimated that 16–24% of irrigation water and 20–25% of irrigation expenses can be reduced compared to traditional flood irrigation practices, without any notable decrease in yield. Although there is no significant difference in grain and biomass yield between AWD and continuous flooding, water efficiency has been found to be notably greater with use of AWD. Increase in yield and the enhancement of water efficiency could be attributed to increase in number of productive tillers brought about by lowering the angle of top leaves, leading to more light entering canopy and altering the shoot and root activity. This result in extraction of more water from soil, which is effectively transformed into dry matter production, thereby leading to better allocation and reallocation of photosynthates into grain, resulting in higher yields even under water-restricted conditions.

Benefits of AWD

Soil structure: Increased soil aggregation and macro-porosity, reduced flooding with AWD may result in improved soil structure for upland crops that will be grown after rice. Deeper root accumulation and greater aeration may have an impact on soil structure, with effects being most noticeable at lower depths. The transition to dry-direct sowing and aerobic rice may also be facilitated by improved soil structure.

Mechanization: Better tillage, traction and soil load bearing

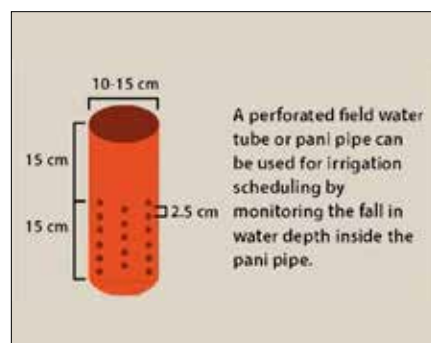
capacity may be provided by improved soil structure, i.e. macro-porosity and aggregation from AWD. This increases the versatility of kinds of equipment and increases the efficiency of the machinery (a limiting factor in current rice mechanisation and its adoption).

Soil moisture control: More effective and timely harvesting, planting, fertiliser application and crop water needs can be met with the use of improved irrigation equipment, laser land levelling and field water level tubes. This can increase crop yields, crop turn around potential and weather resiliency.

Root and tiller development: AWD frequently increases the depth/density of rice roots, improving drought, disease and lodging tolerance as well as nutrient and water intake. The better soil structure for root exploration and oxygenation is to blame for this. AWD can also improve performance.

Phytotoxin removal: With AWD, increased aerobic periods can prevent the accumulation of phytotoxins like phenolic acids, hydrogen sulphide and too much iron and manganese that result from anoxia.

Soil fertility and quality: AWD's increased organic matter decomposition lessens the requirement for comprehensive agricultural residue removal (a standard practice due to its impediment to planting). AWD or highland crop rotations in more aerobic soils can reduce methane emissions. Remainder integration is desirable for non-conventional farming systems due to the added benefits of residue on soil quality and soil carbon.



Perforated Pani pipe



Pani pipe installation at AWD plot



AWD farmers experimental plot in adopted village Bhusia, Banka, Bihar

grown in different soil types and settings.

- Anaerobic and aerobic decomposition of soil organic carbon quantity vs. quality, improved residue management for AWD.
- Rotating rice and aerobic crops as a pest management technique.
- Long-term effects of AWD on soil salinity.

SUMMARY

Although several studies have examined impact of AWD on factors such as grain yield, water efficiency, nitrogen use efficiency, GHG emissions, etc. A thorough evaluation of effects of this method of rice cultivation on soil health, crop quality and environmental sustainability is still needed to fully understand it as a viable alternative to traditional flooded rice farming practices. Globally, AWD in rice production has been shown as a successful and environmentally friendly method. Efforts are underway to make it a viable option in water-scarce areas. Compared to continuous flooding, using mild to safe AWD can result in lower water usage while still maintaining or improving yield. However, using severe AWD leads to a decrease in overall water usage, but also a decrease in yield. Research has shown that most lowland rice variety can tolerate a 30% reduction in total irrigation volume without significant reduction in yield. This allows soil to dry out before re-irrigation, thus reducing use of irrigation water.

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Soil health: Under aerobic conditions, soil microbial and invertebrate activity in the root zone may increase, resulting in improved nutrient cycling and biological tillage. This makes it possible to reuse organic fertilisers for later crops that are frequently trapped in submerged soils. Decreased flooding is known to promote the macro fauna of the soil, including earthworms, which enhance the physicochemical characteristics of the soil.

Way forward

AWD is widely regarded as a promising method for reducing GHG emissions from irrigated rice-agro production system. This technology is essential for adaptation of farmers in smart agricultural production system. AWD is a practical way to maintain or increase rice yields in the face of potential water shortages and the need to enhance land productivity through crop rotation and mechanization.

Studies have shown that in addition to the primary advantages of AWD (lower emissions, water use and pump costs), there are numerous co-benefits that can enhance socio-economic, environmental and agronomic aspects of rice production. AWD adoption and its benefits will be successful if site-specific factors such as climate, soil type, pests, kind of rotation, and irrigation access are taken into consideration. Further research will be necessary to comprehend these site-specific characteristics and the possible downsides of more aerobic regimens in rice. Research is required on the additional advantages of AWD, including but not limited to:

- Effects of water conservation from AWD on biodiversity, ecosystem services, human health and the economy of natural resources.
- Impact of AWD on labour productivity and gender equity.
- Yield difference between flooded rice/aerobic crops



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