A REVIEW ON PRODUCTION OF RICE IN WATER DEFICIENT REGIONS

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ABSTRACT

Rice output in Asia must grow in order to feed an ever-increasing population. Despite the fact that the water deficit for rice in Asia is still being evaluated, data indicates that a decrease in water quality and availability is placing the irrigated rice system in jeopardy. Drought is one of the major reasons for the high yields of rain-fed rice. In order to ensure food security and satisfy the world's hunger need, different methods of growing rice with little water are required. The article examines a systematic strategy to increasing rice yields and decreasing water requirements for rice cultivation that includes genetics, breeding, and integrally managed capital. Various water-saving irrigation techniques, such as saturated-soil cultivation and alternate wetting-drying, may reduce wasteful water discharges while constantly increasing water productivity. Additional contemporary techniques for increasing water efficiency without sacrificing returns are being investigated. Incorporate the C4 photosynthetic pathway in rice to improve yield per unit of water, utilize molecular biotechnologies to promote drought tolerance, and cultivate "aerobic rice" in non-flooded soil to produce a healthy and safe yield.

KEYWORDS:*Drought, Irrigation, Irrigated Rice, Rain-Fed, Water Management.*

1. INTRODUCTION

Water scarcity has been more prevalent globally in recent years. Asian nations are under enormous pressure to reduce water use, since 90 percent of the world's fresh water is diverted. Rice is an easy water management goal since it covers more than 30% of irrigated land and uses 50% of irrigation water. If the conserved water is exported to high-competitive regions, it will help society and the environment by reducing the usage of water in rice cultivation. The 10% reduction in water volume required to irrigate rice would save 25% of the anticipated fresh water used for non-agricultural purposes globally, or approximately 150,000 million m3. Rice, on the other hand, is very sensitive to water pressure. The various methods for reducing water usage in rice production will result in poorer performance and put Asia's food safety at risk. Reduced rice water intake would result in a shift from submergence to aeration in soil aeration. Our goal is to develop new rice-based systems that are socially acceptable, commercially viable, and ecologically friendly, allowing rice production to be maintained or expanded in the face of diminishing water supply. This article looks at the present status of rice supply in rice-growing areas, as well as the benefits and drawbacks of producing rice with less water (1,2).

As a consequence of the use of different irrigation methods aimed at conserving water, rice fields will transition from anaerobic to fully or partially aerobic. These will make significant advancements in water conservation, organic soil turnover, fertilizer dynamics, carbon sequestration, soils, weed biodiversity, and greenhouse gas pollution. Some of these improvements are seen as positives, such as water reuse and decreased methane emissions, while others, such as surface nitrous oxide release or agricultural soil reduction, may be viewed as negatives. The aim would be to develop effective integrated natural resource management measures that enable rice to be cultivated economically with improved soil aeration while maintaining rice-based productivity, environmental services, and long-term sustainability (3–5).

1.1. Rice-Producing Areas and Available Water Resources:

Rain-fed rice accounts for around 45 percent of worldwide rice production. Drought was one of the main constraints in the rainfed lowlands and all the rain-food mountains that are prone to drought, with an average of 2.3 t ha-1. Droughts, both severe and mild, are frequent in rice-growing areas such as Laos, northeastern Thailand, Central Myanmar, and northeast and east India.

Rice is grown over 79 million hectares of irrigated lowlands, which account for around 75% of total rice production. Rice production in Northern and Central China, Northwest India, and Pakistan is mostly dependent on wet-season plant precipitation with supplemental irrigation. Throughout the dry season, irrigated rice may be found in Southeast and East India, Southeast Asia, and South China. In the irrigated rice area, a thorough assessment of water availability for irrigation is lacking. By 2025, Pakistan, north China, and north and central India's dry-season irrigated rice areas are expected to run out of physical water. In addition, during the dry season in central India, nearly two million hectares of irrigated rice will be physically scarce. The 'economic water deficit' area includes the bulk of South and Southeast Asia's roughly 22 million hectares of dry season irrigated rice crops. However, since water shortage predictions are based on yearly groundwater recharge, dry season water resources may be overestimated. Water is always limited during the dry season, since the lack of rain makes irrigation difficult. Physical water limitations in the commercial water scarcity zone may impact rice crops during the dry season.

Water problems currently dominate rice-growing regions, according to data. Over-exploitation of groundwater in China and South Asia has caused major difficulties in recent decades. Higher pumping costs, salt penetration, fluoride contamination, land decrease, and fractures and sinkholes have all resulted as a result. These large groundwater-depletion regions impact rice-wheat-growing areas in northern India, as well as rice-growing areas in Tamil Nadu, Pakistan, and China. Groundwater overdrawing in Bangladesh causes rice fields to dry up during the summer months, but water is replenished during the monsoon season. The emergence of toxic arsenic, which is related to the region's decreasing groundwater level, is a specific issue (6).

Strong upstream water use along several of Asia's major rivers is exacerbating water shortages downstream. Because of the high demand for water, the final 600 kilometers remained dry for more than four months in 1997. In the Beijing area, the Chinese government has declared it illegal to cultivate flooded rice. The fact that fierce rivalry between governments and different industries for rice-growing regions has resulted in water shortages in Thailand's Chao Phraya delta and southern India's Cauvery is less dramatic, but more important.

In addition, irrigated rice farming faces competition from other sectors. China's irrigated rice fields shrank by 4 million hectares during the 1970s and 1990s. Although the reduction in irrigated rice area cannot be attributed entirely to water scarcity, indications suggest that the reduced area of water carried into irrigated rice is linked to water scarcity. Zhanghe's 160,000-hectare irrigation system was dominating until the 1980s, when the water was transferred to irrigation. When compared to the 1980s, the area irrigated rice fell by approximately 20% in the 1990s. As a consequence, rice production was also hampered. In Asia, there are similar examples of heightened competition. Water from the Angat River in the Philippines is progressively being diverted to Manila, reducing water supplies downstream for agriculture. Other areas are endangered by degraded water quality, which is exacerbated by human contamination. The water of the Agno River in Pangasinan Province has been contaminated by sediments and pollutants from upstream mining operations (7).

2. LITERATURE REVIEW

Yasuhiro Tsujimoto et al. describe how the usage of fertiliser input for rice cultivation in Sub-Saharan Africa may increase agricultural productivity returns, such as grain per kg of N relevant (AEN). The findings of the experiments indicate that irrigated and rainfed soil geographic variations may enhance the value of AEN in the soil. Major variations in small-scale topography also affect AEN in rainfed agricultural systems, causing complicated hydrological shifts and changes in the contents of soil organic carbon and clay. Low-cost UAV-systems for micro-topography collecting, a high-resolution soil nutrient data base, better SSA fertilizer mixing, and immersive decision support instruments utilizing mobile phones are among these capabilities. Small-dose fertilization of nursery in challenging terrain conditions in Sub-Saharan Africa is another method to improve AEN (8).

Shaobing Peng et al discussed chinese farmers have difficulties in rice production. China's rice output has more than quadrupled in the last five decades, owing to higher grain yields and expanded planting areas. This increase has been attributed to the development of high-yielding crops as well as improved agricultural management techniques such as nitrogen fertilizer and irrigation. However, rice production in China has been stagnant for the last 10 years. If per capita rice consumption continues at its current level, China would need to produce 20% more rice by 2030 to meet domestic requirements due to its growing population. It's a problem since China's capacity to produce rice sustainably is limited by a variety of innovations and difficulties in the rice production system. Arable land degradation, increasing water scarcity, global climate change, and labor shortages are all significant issues. A lack of genetic history, excessive use of pesticides and fertilizers, failing irrigation infrastructure, excessively simple plant care, and inadequate expansion plans are all factors in Chinese rice growth. Despite these obstacles, China's rice output may be improved with efficient research methods. Development of novel rice varieties with high potential returns, increased resistance to major diseases and insects, and abiotic stress such as drought and heat, as well as integrated crop management, are all part of the process. We believe China will achieve long-term rice production growth as a result of new technologies and rice science (9).

T.P. Tuong et al. looked at new methods for combining genetic engineering, integrated resource management, and breeding to boost rice output while lowering irrigation water needs. Irrigation, such as wet soil irrigation and alternating watering and drying, would significantly reduce wasteful water output and increase water production. However, the majority of lowland rice cultivars now in use generate lower yields. More innovative techniques for increasing water production without sacrificing yields are being investigated. The C4 photosynthetic mechanism is integrated into the rice in this manner to improve unit water efficiency, boost drought resistance using molecular biotechnology, and cultivate "aerobic rice" to provide excellent and steady harvests in non-flooded soil. As a consequence of the use of water-conserving irrigation techniques, Rice fields may go from being completely anaerobic to being partially or completely aerobic. Water management and investment would be influenced by changes in soil organic matter turnover, nitrogen dynamics, carbon sequestration, soil productivity, crop biodiversity, and greenhouse gas pollution. While some of these changes are beneficial, such as increased water efficiency and reduced methane emissions, others, such as the release of nitrous soil oxides and the removal of organic soil, are harmful. Rice output in Asia must expand to feed a growing population. While a thorough assessment of the water scarcity rate in Asian rice production is still lacking, indications suggest that decreasing water quality and a decreased water supply pose a danger to the irrigated rice scheme's continuation. Drought is a significant constraint on rain-fed rice yields (7).

3. RICE PLANTATION

In Asia, lowland rice is often transplanted into flooded lowland paddy fields. Paddy land planning includes procedures such as soaking, plowing, and puddling. Puddling is mostly used to control weeds, although it may also be used to improve soil permeability, water absorption, transplanting, and field leveling. Soaking is a one-time procedure that produces water penetration and the formation of a battered water surface on top soil. In large irrigation systems, there are often "idle intervals" between working and transplanting, which may extend the field preparation process by up to 12 months. The crop is growing from the time of transplanting until the time of harvest. During this time, fields are typically covered with 5-10 cm of water, with the last runoff occurring 10 days before harvest.

In flooded settings, water is required to deal with outflows (percolation (P) and seepage (S) to the environment, as well as depletions (transpiration (T) and evaporation (E) to the atmosphere. The water head on the ground and the water resistance movement across the soil define the flow rates S and P. Sometimes the letters S and P are combined to form a single word. SP, since they are difficult to distinguish in the domain. Because soil fracture cannot fully seal after ground soaking, SP in land preparation may reach 25 mm per day. Only E happens during land planning, while both E and T occur during crop growth. Evapotranspiration is also known as ET since the difference between E and T is difficult to detect during crop formation. Rice ET prices in Asia are typically between 4 and 7 mm per day.

3.1. The Productivity of Water:

The quantity of cereal results obtained per unit of water is referred to as water productivity. Water productivity is measured in terms of total grain yield per unit water input (WPIP) or grain yield per unit water evapotranspired (WPET), depending on the type of water flow. In the field, WPET levels range from 0.4 to 1.6 g kg-1 under typical lowland circumstances, whereas (WPIP) values range from 0.20 to 1.1 g kg-1. WPET's large range exemplifies the significant fluctuation in rice yield and ET produced by changing growth circumstances. WPET levels in rice are only slightly lower than in other C3-type food crops like wheat. Rice, on the other hand, has a (WPIP) value that is about half that of wheat. Rice has a poorer (WPIP) score because to the strong infertile discharges mentioned previously as SP and E. Apart from the quantity and yield of field water outflows, the boundaries and scale of the area in which water productivity is evaluated have a major effect on its significance. This is due to the fact that S, P, and wastewater outflow losses in one part of the sample area may be duplicated in another. Water efficiency data may be analyzed at various sizes to see whether upstream water discharges are effectively reused downstream. For irrigation systems, there has been a scarcity of solid data on the quality of water at various levels (Table 1). The results show that water productivity varies substantially from that in the field and is below the range of productivities on the bottom level. Data on water efficiency at sizes larger than a field are scarce because:

a. Data on produce, flows of water, or both at certain scales; and

b. Collaboration among agricultural and water-management professionals.

TABLE 1: THE PRODUCTIVITY OF WATER WITH RESPECT TO IRRIGATION, EVAPOTRANSPIRATION AND OVERALL WATER INPUT AT VARIOUS SCALES.

Area (ha)	WP_{ET}	(WP_{IP})	WPI	Location
30–50	0.5–0.6	0.25–0.27	1–1.5	Muda irrigation system, Kendal, Malaysia
287–606	1–1.7	-	0.4–1	Zhanghe irrigation system Hunan, China
Over 10^5	-	0.5–1.3	1–2.5	-

3.2. Techniques for Enhancing Productivity of Water:

Increasing water efficiency can be achieved by considering following points:

(i) ET accumulated increases in yield per unit;

(ii) Reduced water outflows and depletions that are not productive (SP, E); or

(iii) Ensuring the rainfall is best used. The final solution is economically as well as environmentally important because rainfall will complement or replace the water which needs to be supplied by irrigation.

3.2.1 Agronomic Practices and Germplasm Development:

The development of germplasm has helped increased water efficiency in rice cultivation. In compared to traditional kinds, new varieties show almost a threefold increase in water productivity by increasing yield while simultaneously lowering crop duration. Cultivars introduced before 1980, on the other hand, accounted for the bulk of WPET increase. This is due to the fact that between 1966 and the beginning of the 1980s, the rise in yield was accompanied by a reduction in growth. As tropical japonicas and hybrid rice grow more established, water productivity will increase.

In low-fertility, drought-prone rain-fed environments, breeders have had the greatest success utilizing drought alleviation. Drought exposure may be minimized by shortening crop rotations or minimizing the number of susceptible crop phases that coincide with water shortages. Drought resistance breeding has advanced more slowly, and the issues encountered are often ascribed to the trait's genetic diversity and environmental interaction. Drought-resistant cultivars were developed and released in both highland and low-lying rain-fed regions.

Improved agronomic methods, such as efficient weed management, site-specific fertilizer control, and appropriate field leveling, will significantly increase rice production without compromising ET, possibly boosting water productivity.

3.2.2 Minimizing Inactive Periods throughout the Preparation of Land:

Transplant rice seedlings are usually fed in the seedbed for 2-4 weeks. Most fields surrounding seedbeds are tilled and watered with tertiary and field-to-field irrigation systems during this period. With access to the services, farmers may reduce the land planning phase by encouraging them to:

i. Provide water directly to the nursery without having to submerge the main fields; and

ii. Carry out their agricultural operations regardless of the weather.

Farmers in Malaysia's Muda irrigation systems were able to shorten field preparation periods by increasing drainage power from 10 to 30 m ha in 25 days, saving 375 mm of water per year over two rice-growing seasons. This is due to an increase in the time it takes to prepare the water.

During the ground design, direct planting seems to be another option for minimizing idle time in irrigation systems without tertiary canals. In the main sector, however, transplanted rice has a shorter crop development period than straight seeded rice. For the water saved by direct seeding, a balance between reduced water use via reduced land planning and expanded water usage through a longer growth phase in the primary industry is estimated.

Changing the soil's physical characteristics will make it more resistant to water movement. Puddling results in a compacted, well-compacted soil that stops water from flowing upward. In North-East Thailand, heavy compaction machines have been shown to reduce soil permeability by at least 5% clay in sandy and loamy soils. Researchers have also attempted physical barriers such as bitumen deposits and plastic coverings beneath paddy soils. For most farmers, however, soil compaction and physical barriers are expensive and beyond of their control.

3.2.3 Utilization of Rainfall More Efficiently:

The development of dry-seeded rice has the potential to conserve a lot of water by making better use of rainfall. Farmers in both transplanted and wet-sown rice systems usually wait until the field is emptied before ordering canal water. The processing of dry-sown rice begins with early monsoonal rains and takes place in dry or humid soil. Crops are planted and begin to grow early in the monsoon, and the crop is only watered later when the canal's water supply is sufficient. However, all three crop-establishment operations were found to have similar total water input and water productivity in terms of total water output. Due to the early establishment of the crop, dry seeding also allows farmers to produce an additional crop after harvest utilizing leftover soil moisture or conserved irrigation water. In stringent rainfed systems, rice plants may avoid a later-season drought and increase production and dependability in early establishment and harvesting of dry-seeded rice.

4. DISCUSSION

Saturated soil cultivation (SSC) requires careful field water management and frequent, labor-intensive shallow irrigation rotations. The experiment is being conducted in Australia with raised beds to encourage SSC activities. Water in the furrows kept the beds (120 cm wide) wet. Water reductions were 34 percent and yield losses were 16-34 percent as compared to flooded rice. The SSC was shown to reduce both irrigation-water intakes and yields by slightly over 10% in southern New South Wales, Australia, thus preserving water productivity. Due to cold damage, the new cultivars cultivated with SSC are expected to reduce yields in this region. The test's findings indicate that further study is needed to fill in the water balance components, which are responsible for disparities in overall water usage. Under the Muda irrigation system in Malaysia, dry rice enhances irrigation water production significantly in wet seeds and transplanted rice (Table 2).

TABLE 2: THE MEAN ± SE OF WATERS PRODUCTIVITY AND GRAIN YIELD. THE NEW VARIETIES GROWN WITH SSC ARE LIKELY TO DECREASE YIELDS DUE TO COLD DAMAGE IN THIS AREA.

Parameter	WS ISU	DS ISU	TP ISU
Yield	$4.50 \pm 0.23^{a,b}$	4.14 ± 0.17^{b}	4.79 ± 0.23^{a}
WP(I)	0.62 ± 0.30^{b}	1.48 ± 0.26^{a}	1.00 ± 0.30^{b}
WP(I+R)	0.26 ± 0.02^{a}	0.27 ± 0.02^{a}	0.25 ± 0.02^{a}
WP(ET+E)	0.42 ± 0.02^{a}	0.38 ± 0.02^{a}	0.39 ± 0.02^{a}
WP(ET)	0.53 ± 0.04^{b}	0.48 ± 0.03^{b}	0.61 ± 0.04^{a}

After rice, a crop such as wheat may benefit from the SSC and the growing rice. Spring irrigation and winter plant output after rice are continuously decreased in physical structure and logging due to bad soil. For a post-rice crop, a bed system may assist with drainage.

Soil submergence is a unique characteristic of irrigated lowland rice ecosystems. Continuous fertilizer supply, soil carbon levels, and rice production patterns indicate that lowlands producing two or three harvests of rice per year on submerged soils are highly functional. The anaerobic decomposition of organic matter, on the other hand, is aided by soil submergence, resulting in the production of methane, a major greenhouse gas. Temporary soil aeration, like as that employed in AWD, may decrease methane emissions. Long-term soil aeration, such as that seen in aerobic rice, will further decrease methane emissions. Soil aeration, on the other hand, will enhance nitrous oxide emissions, which are a greenhouse gas. Methane and nitrous oxide emissions are strongly related to soil redox potential, which is an indication of soil oxidation state. It is suggested that all methane and nitrous oxide emissions may be minimized by maintaining the soil redox potential between –100 and +200 mV.

Better aeration of AWD soil and aerobic rice will improve the condition of soil organic matter and nutritional potential. It may also make seed residue retention more difficult. More active weed flora linked with water-saving technology may need a greater dependence on pesticides, putting the ecosystem at danger. The quantity of water and soil required for rice ecosystem resources and productivity may be significant issues for water-saving methods.

5. CONCLUSION

Rice growth has been predicted in perpetually flooded regions for decades, but the coming water crisis will change rice growing techniques. Researchers are re-examining irrigation methods that were explored in the late 1970s for water conservation, such as Alternate Wetting and Drying (AWD). The basic components for putting these ideas into action seem to be in place. With the exception of China, however, the adoption of these technologies has been sluggish. The goal is to discover environmental and socioeconomic variables that enable farmers to take advantage of them. In this area, our investigation is far from complete. However, we can identify key variables influencing farmers' willingness to adopt water-saving technologies. In contrast to fertilizers and pesticides, water is seldom offered on Asian markets, and government-mandated irrigation waters are either inadequate or non-existent. If water becomes a measurable economic benefit, farmers are more inclined to use water-saving technologies. Farmers in Asia that face high water expenses are already employing this technology, according to statistics. Farmers in north-central India who use pumps to water their crops utilize some kind of AWD to save money on pumping. Water trade, which allows farmers to sell their water rights to others, has also been viewed as a way for farmers in Australia to adopt water conservation measures.

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