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An Overview on Production of Rice in Water Deficient Regions

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ABSTRACT: Rice output in Asia must expand to feed the population constantly growing. Whilst a thorough assessment of the water deficit in Asian rice production continues, there are signs that the sustainability of the rice irrigated system will be threatened by deteriorating water quality and water supply. Drought is one of the primary constraints on large yields of rain-fed rice. Asia must find ways to cultivate more rice with less water, in order to ensure food safety and environmental health. This study explores the entire approach of the International Rice Research Institute to increase rice output and to reduce consumption for rice production, including genetics, breeding and coordinated resource management. The saving of water irrigation techniques such as saturated soil cultivation and alternate wetting and drying will substantially lower unproductive water drains and continue to increase water production. Additional contemporary technologies are being explored to improve water productivity without losing output. The C4 pathway in rice is included to enhance output per unit of water transpired, to improve drought resistance by utilizing genetic biotechnology and to produce 'aerobic rice' for good and safe outputs of unflooded land.

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

1. INTRODUCTION

Water shortages have risen around the world in recent years. Asian countries are put under enormous pressure to reduce the use of water, with 90% of the entire fresh water being diversional. As rice grows on more than 30% of irrigated soil, it represents 50% of irrigated water, and rice is viewed as a straightforward target for water management. If conserved water is transferred to highly competitive places, it will help society and the atmosphere by limiting the use of water in rice cultivation. But on the other hand, rice has significant water tension susceptibility. Attempts to limit the use of water in rice cultivation can lead to poorer output, further threatening the food security of Asia. Reduced rice water use would move from submergence to aeration in soil aeration. Our objective is to build new, economically feasible and ecologically sustainable rice systems that can sustain or expand rice production in response to decreased water supplies. This document analyses the present status of water resources in rice-growing regions and the benefits and inconveniences of rice cultivation with less water [1].

Rice fields can change from being constantly anaerobic to being partially or even fully aerobic as a result of the introduction of water-saving irrigation technologies. These will undertake major improvements for the protection of water, the turnover of organic soil, the dynamics of fertilizer, carbon sequestration, soils, and biodiversity of weeds and pollution of greenhouse gases. The goal would be to establish successful integrated natural resource management actions that allow rice to be grown profitably with increased soil aerations while preserving rice-based production, environmental services and sustainability.

1.1 Water Resources Present in Rice-Producing Areas:

Rice may be cultivated under irrigated conditions or with rain-fed conditions. Rain fed rice accounts for about 45% of global rice supply. Drought was one of the principal yield improvement constraints which currently amount to an average with 50% of the rain-fed lowlands and all rain-fed highlands vulnerable to drought. In largely rain-fed rice areas such as northeast Thailand, Laos, central Myanmar, east and north-east India, severe and moderate droughts occur frequently[2].

In addition, over 2 million hectares of irrigated rice grown in the dry season in central India would be physically scarce. The ‘economic water shortage' region encompasses the majority of the approximately 22 million hectare of dry season irrigated rice fields in South and Southeast Asia. However, since IWMI's water-scarcity estimates are based on the annual water balance, there could be an overestimation of water supply during the dry season. Water is still scarce in the dry season, as a lack of rain makes cropping difficult without irrigation. In the dry season, rice areas in the ‘economic water scarcity' region may be influenced by ‘physical water scarcity’[3].

Data has shown that rice growing areas are now dominated by water shortages. Over recent decades, the over-exploitation of groundwater in China and South Asia has created significant problems. Groundwater tables in Punjab, Haryana, Rajasthan, Maharashtra, Karnataka and northern Gujarat fell on average by 1-3 m in a year and hard Rock Southern India by around 1 m in a year. This has contributed to higher pumping costs, saline penetration, fluoride pollution, land reduction and cracks and sinkholes[4]. The rice-wheat growing areas of northern India as well as the rice-growing areas of Tamil Nadu, Pakistan, and China are affected by these big groundwater-depletion areas. Overdrawing of groundwater in the Ganges delta of Bangladesh allows wells to dry up in rice-producing areas during the dry season, but water levels are restored during the rainy season. The appearance of poisonous arsenic is a particular problem linked to declining groundwater level in this region[5].

Water shortages downstream are being exacerbated by strong upstream water consumption along some of Asia's main rivers. Since 1972, China's Yellow River, which runs for 4600 kilometers across some of Asia's richest farmland, has been nearly dry last year. Because of the strong demand for its water, the last 600 kilometers became dry for more than four months in 1997. China's government has made it illegal to grow flooded rice in the Beijing region. During the dry season in South Asia, the Ganges and Indus Rivers have little or no outflow to the sea. The reality that strong competition between states and various sectors for rice growing areas causes water shortage in southern India's Cauvery and in the Chao Phraya delta in Thailand is not so drastic, but more significant[6].

Furthermore, irrigated rice cultivation is faced with competition from other industries. Between the 1970s and 1990s, China's irrigated rice field fell by 4 million hectares. Although the decrease in irrigated rice area cannot be said solely because of the water shortage, there are signs that the decreased area is linked to the decrease in water that is transported into irrigated rice. For example, the 160,000 ha irrigation system in Zhanghe was dominant until the 1980s,

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when the water was diverted to irrigation[7]. Following that, Zhanghe river water was gradually used to satisfy the rising demand for water by cities and industry, as well as for hydropower production, and irrigation water allocation dropped to around 20% in the late 1990s. In the 1990s, the irrigated rice region decreased by around 20% compared to the 1980s (Figure 1). Rice yield was also limited as a result. Similar instances of intensified rivalry can be found in Asia. Water from the Angat River in the Philippines' Bulacan Province is gradually being diverted to Manila, reducing downstream water supply for agriculture. Water supply in other areas is endangered by degraded water quality exacerbated by industrial waste. Sediments and contaminants from mining operations upstream have poisoned the water in the Agno River in Pangasinan Province.

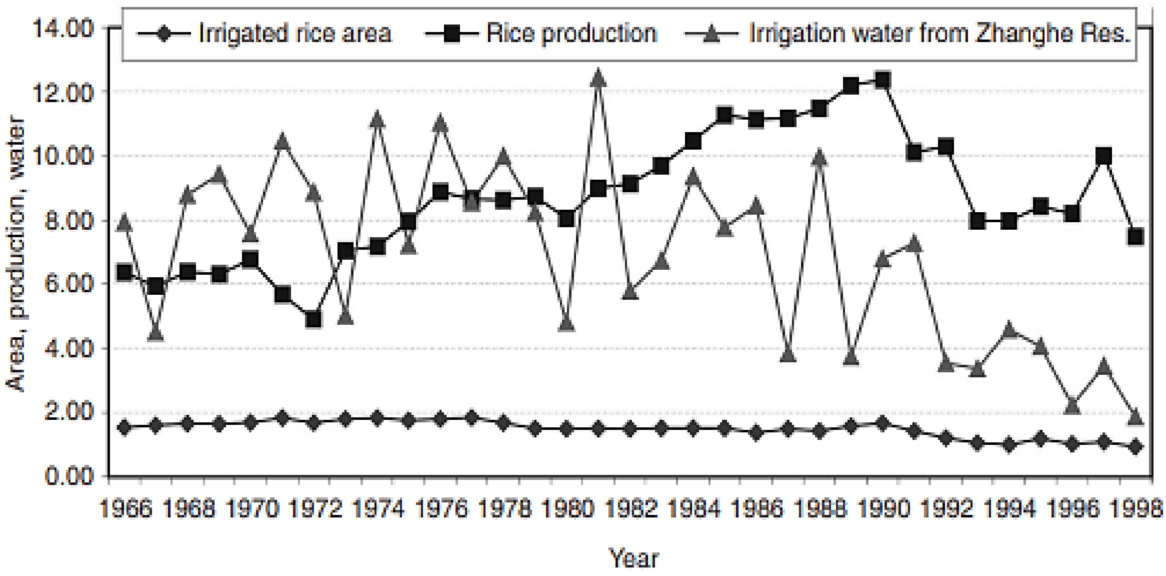

Figure 1: Irrigated rice area, irrigation water and rice production from reservoir (1966–1998), Hubei province, Zhanghe irrigation system, China [8]**.**

1.2 The Productivity of Water:

The amount of grain yield produced per unit of water is referred to as water productivity. Water productivity can be described as grain yield per unit water evapotranspired (WP_{ET}) or grain yield per unit total water input (WP_{IP}), depending on the form of water flows considered. WP_{ET} Values in the field vary from 0.4 to 1.6 g kg^{-1} under normal lowland conditions, while (WP_{IP}) values range from 0.20 to 1.1 gkg^{-1}. The wide range of WP_{ET} illustrates the wide variance in rice yield and ET caused by variations in growing conditions. Rice's WP_{ET} levels are just marginally smaller than those of other C3-type food crops like wheat. Rice, on the other hand, has a (WP_{IP}) that is about half that of wheat. Rice's low (WP_{IP}) is primarily due to the strong unproductive outflows described earlier (SP and E). Aside from the yield and size of field water outflows, the scale and boundary of the region for which water productivity is measured have a significant impact on its importance. This is because the outflow ‘losses' caused by S, P, and drainage at one site can be replicated at another within the study region. Water productivity data at various scales may be used to determine if water outflows from upstream are

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successfully reused downstream. We've only found a few credible data on water efficiency at various scale sizes within irrigation systems so far (Table 1).

The results show that water productivities at scales greater than the field level differ greatly and are within the range of field-level water productivities. Data on water efficiency at scales greater than the field level are scarce due to the lack of:

- Data on water flows, yield, or both at certain scales; and
- Collaboration between agricultural and water-management professionals.

Table 1: Water productivity in respect of evapotranspiration, irrigation and total water input at different 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	-

1.3 Techniques for Enhancing Productivity of Water at the Field Level:

At the field level, increasing water efficiency can be achieved by (i) increasing yield per unit accumulated ET; (ii) reducing unproductive water outflows and depletions (SP, E); or (iii) allowing better use of rainfall. The last approach is relevant from both an economic and environmental perspective, as the water that needs to be supplied by irrigation can be supplemented or fully replaced by rainfall.

1.3.1 Agronomic Practices and Germplasm Development:

Increased water efficiency in rice production has been aided by the invention of germplasm. In comparison to conventional varieties, new 'IRRI varieties' have about a threefold rise in water productivity by raising yield while simultaneously reducing crop length. However, cultivars launched before 1980 accounted for the majority of the growth inWP_{ET}. This is because, from 1966 to the early 1980s, the rise in yield was followed by a decline in growth length, while cultivars released just after mid 1980s had such a longer duration than any of those released since 1980. Water productivity will improve as tropical japonicas and hybrid rice become more established.

Breeders have had the most success exploiting drought relief in low-fertility, drought-prone rain-fed ecosystems. Drought exposure is reduced by decreasing crop length or reducing the likelihood of vulnerable crop phases coincident with water-deficit cycles. Drought resistance breeding has progressed more slowly, and the problems faced are often attributed to the trait's genetic variability and contact with the environment. Drought-resistant varieties have been developed and released in both upland and rain-fed low-lying areas. Salinity-tolerant rice varieties, such as Ir51500 AC11-1, help us to grow rice in places where salinity issues prevent us from growing traditional lowland varieties.

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Improved agronomic techniques, such as site-specific fertilizer control, effective weed management, and proper land leveling, will greatly improve rice yield without affecting ET, potentially increasing water productivity.

1.3.2 Minimizing Inactive Periods Throughout Land Preparation:

Seedlings in transplanted rice are typically nurtured in a seedbed for 2-4 weeks. During this time, all fields surrounding the seedbeds are tilled and flooded in irrigation systems without tertiary and field channels, as well as field-to-field irrigation. The availability of tertiary facilities will shorten this land-preparation cycle by allowing farmers to: (i) supply irrigation water directly to the nurseries without having to submerge the main fields; and (ii) carry out their farming practices independently of the surrounding fields.

Changing the physical properties of the soil will increase the resistance to water flow. Puddling thoroughly produces a well-compacted plough soil that obstructs vertical water flow. In northeast Thailand, heavy machinery compaction has been shown to reduce soil permeability in sandy and loamy soils of at least 5% clay. Physical walls, such as bitumen deposits and plastic covers, have also been tried under paddy soils by researchers. Soil compaction and physical obstacles, on the other hand, are costly and out of control for most producers.

1.3.3 Utilization of Rainfall More Efficiently:

Dry-seeded rice innovation provides a huge potential to save irrigation resources by more successfully using rainfall. Farmers in transplanted and wet-seeded rice systems usually wait for canal water distribution before starting land soaking. Land preparing for dry-seeded rice is performed in either dry or moist soil properties, and it starts with early monsoonal rainfall. Crop emergence and early growth often happen early in the monsoon, and the crop is only irrigated when needed later, when canal water is available. In terms of total water production, however, all three crop-establishment activities were found to have comparable total water input and water productivity. Dry seeding also has the benefit of allowing farmers to grow an extra crop after harvest using remaining soil moisture or saved irrigation water due to the early establishment of the crop. Early establishment and harvest of dry-seeded rice in strictly rain-fed systems helps the rice plants to avoid any late-season drought, improving yield and reliability.

2. LITERATURE REVIEW

Shaobing Peng et al. analyzed the difficulty in rice production faced by Chinese farmers. Over the past five decades, Chinese rice production has more than tripled mostly due to increased grain yields and more seeding areas. The production of high yielding crops and better crop management practices including nitrogen fertilization and irrigation has contributed to this rise. In the last ten years, though, rice has stagnated in China. A reduction in arable land, rising water scarcity, global climate change, labor shortages, and rising market demand for high-quality rice are all major phenomena. Narrow genetic history, overuse of fertilizers and pesticides, irrigation infrastructure failure, oversimplified crop management, and a poor extension system are the major issues facing rice production in China. Despite these obstacles, effective research strategies will help China increase rice yield. This involves developing new rice varieties with high yield potential, improving tolerance to major diseases and insects, as well as abiotic stresses including drought and heat, and implementing integrated crop management. We assume that with the introduction of new technologies and rice science, China will achieve a long-term increase in rice production[9].

T.P. Tuong et al. reviewed the advanced strategies of International Rice Research Institute, using genetics, breeding and integrated management of resources to increase the rice output and to reduce water demands for rice production. Irrigation which saves water including saturated soil cultivation and alternative wetting and drying will significantly reduce unproductive water outflows and improve water productivity. However, most of the present rice varieties of the lowlands produce a decrease in yield. Water management, soil organic-matter turnover, nitrogen dynamics, carbon sequestration, soil fertility, weed biodiversity, and greenhouse-gas pollution will all be affected by these transitions. Although some of these improvements are beneficial, such as water management and lowered methane production, others are detrimental, such as nitrous oxide release from the soil and a reduction in soil organic matter. While there is still a lack of a detailed evaluation of the water shortage rate in Asian rice production, indicators indicate that deteriorating water quality and a reduced water supply threaten to maintain the irrigated rice scheme. Drought is a major restriction in rain-fed rice yield. For food safety and environmental protection in Asia, exploration of ways to cultivate more rice with less water is crucial[8].

The flood is a generalized natural calamity, which in terrestrial plants leads to oxygen and energy deficits, thereby decreasing their output. Rice is highly flood tolerant, but the fundamental tolerance mechanism remained unclear. Here we showed that CIPK15 protein kinase plays a major role in the tolerance of O2 deficiencies in rice. In order to control and control the synthesis of sugar and energy and enhance the development of rice under the floodwater, CIPK15 modulates the SnRK1A global energy and stress sensor and combines O2 signals with the SnRK1 dependent sugar-sensing cascades. Our findings help to understand how rice thrives in low-land irrigation circumstances of O2 shortage[10].

3. DISCUSSION

Irrigation water habitats of lowland rice have a particular property: flooding of soil. Lowlands producing two to three rice harvests per year on submerged soils are extremely sustainable, as demonstrated by their continued supply of nutrients, soil carbon levels and rice production patterns. But on the other hand, the permanent submergence of soil promotes the direct and significant impact breakdown of organic matter, resulting in the production of methane, a large greenhouse gas. Temporary soil aeration, such as those employed in AWD can minimize methane emissions. Long-term ventilation of the soil, for example with aerobic rice, will further cut methane emissions. Soil ventilation, on the other hand, will boost emissions of nitrous oxides, a greenhouse gas. Evaluating the possibility of such an intermediate redox potential of water-saving technologies is an important area of research. The state of organic soil and the potential nutrition delivery are impacted by enhanced AWD soil and aerobic rice. It can also impede the retention of crop residues. Increased dependency on pesticides and the danger of the ecosystem can result in aggressive weed flora linked to water conservation technologies. How much water is needed and how much soil is needed for productivity and services in the rice ecosystem might be significant problems for water-saving technology.

4. CONCLUSION

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For decades, rice has been growing in constantly flooded fields, but the impending water scarcity will change the way rice is cultivated in the future. Researchers review water-saving irrigation techniques, such as alternate weathering and drying, which were investigated in the early 1970s. The key ingredients for implementing these inventions seem to be in order. The adoption of these improvements was, however, slow, with the exception of China. The aim is to discover the socio-economic and environmental conditions that allow farmers to utilize them. Our study is far from finished in this field. However, we can identify critical elements that impact the readiness of farmers to use water-saving technology. Unlike pesticides, the water, which is seldom sold on Asian markets, is frequently poor or non-existent by government decree. As a result, farmers are not incentivized to use water as a valuable resource. Farmers have little motivation to utilize technology to save water, because water conservation cannot reduce agricultural expenses or generate income. . If the water has become concrete commercial goods, farmers will be more motivated to use water-saving technologies. Farmers have also been shown to be able to carry out water-saving measures in Australia, allowing producers to maximize their rights for water.

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