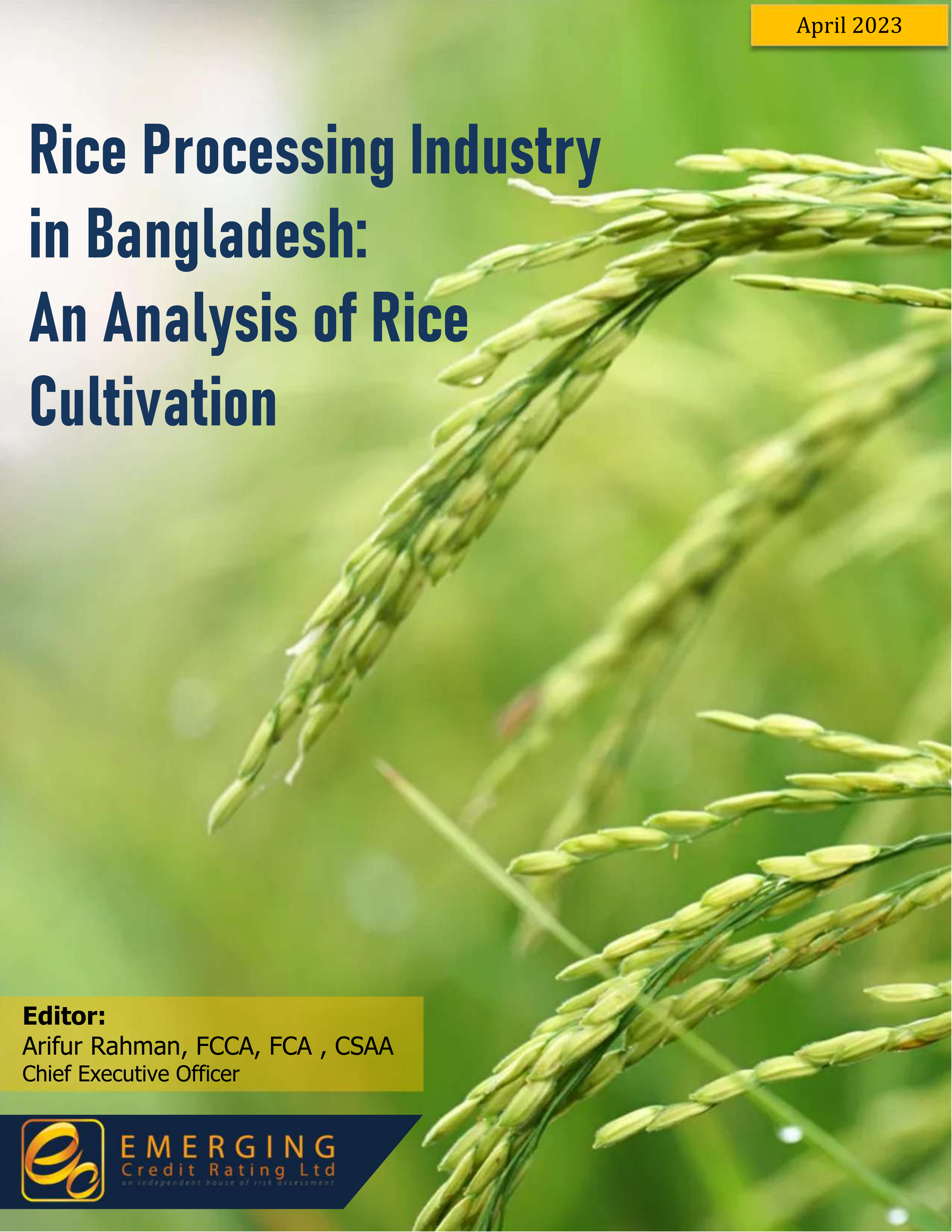

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Rice Processing Industry in Bangladesh: An Analysis of Rice Cultivation

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Abstract

Bangladesh's economy is predominantly agrarian, with rice being the dominant crop. The country's high per capita rice consumption reflects rice's status as the staple food. The nutritional requirements of the majority of the population are met through rice consumption. Over time, the country's rice production has changed in terms of cultivation techniques, cropping patterns, and yield potential. Despite overpopulation pressures, Bangladesh has achieved self-sufficiency in rice production. This review examines the current status and potential future of rice cultivation in Bangladesh.

Introduction

Bangladesh is predominantly agrarian, with approximately 61.05% of its populace residing in rural areas (The Global Economy, 2021). Rice cultivation contributes to almost 48% of rural employment in Bangladesh (BRKB, 2022). Furthermore, rice consumption provides roughly two-thirds of the total calorie supply and about one-half of the total protein intake for the average citizen in the country. Agriculture plays a significant role in Bangladesh's economy, accounting for 11.50% of the country's GDP (Ministry of Finance, 2022). Bangladesh boasts a prolonged history of cultivating rice, a crop grown ubiquitously throughout the nation except in the hilly southeast regions. The country's agroclimatic conditions are conducive to the year-round cultivation of rice. Nonetheless, the average national rice yield is significantly lower (2.94 t/ha) compared to other countries known for rice cultivation (Shelley et al., 2016).

Rice is the primary sustenance for approximately 169 million individuals in the country (Worldometer, 2023). With a population growth rate of 1.6 million per year (Worldometer, 2023), the total population is projected to reach 230-250 million by 2050 (Haider, 2018). This population increase necessitates a corresponding rise in rice production to ensure adequate food supplies. However, cultivable land is decreasing at a rate of over 1% per year due to the expansion of industries, factories, residential areas, and transportation networks (Shelley et al., 2016). Urbanization has also shifted food preferences, with demand for other crops competing for land traditionally used for rice cultivation. To address these challenges, efforts must be made to increase the rice yield per unit area. Furthermore, agriculture faces various adverse conditions due to climate change, such as drought, flood, salinity, extreme temperature stress, and low soil fertility. In this context, policies must be implemented to sustainably increase rice production to secure food and nutritional requirements for the rapidly growing population of this country.

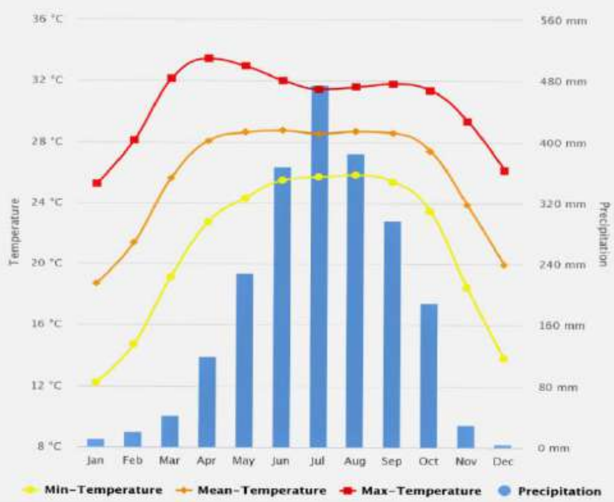
Agroclimatic Condition

Bangladesh experiences a tropical climate characterized by significant fluctuations in climatic variables, particularly temperature and rainfall. The nation's land area covers 14.86 million hectares (147,570 square kilometers), with arable land amounting to 8 million hectares in 2020, reflecting a 0.41% growth from 2019 (macrotrends, 2023). Moreover, the cropping intensity in the country is 191% (Shelley et al., 2016).

Bangladesh experiences a warm and humid climate influenced by pre-monsoon, monsoon, and post-monsoon circulations, resulting in heavy rainfall and tropical cyclones. Although Bangladesh receives a copious amount of rain, its distribution is not uniform across regions or seasons. The country receives approximately 2,200 millimeters (mm) of rainfall annually, with most areas receiving at least 1,500 mm (World Bank, 2023). However, some areas, particularly those in the northeastern border regions, receive up to 5,000 mm of rainfall annually (World Bank, 2023). The monsoon season occurs between mid-June and September, when most precipitation occurs (Figure 1). Conversely, the period between November and March experiences very little rainfall, while the pre-monsoon season between April and May brings rain accompanied by thunderstorms.

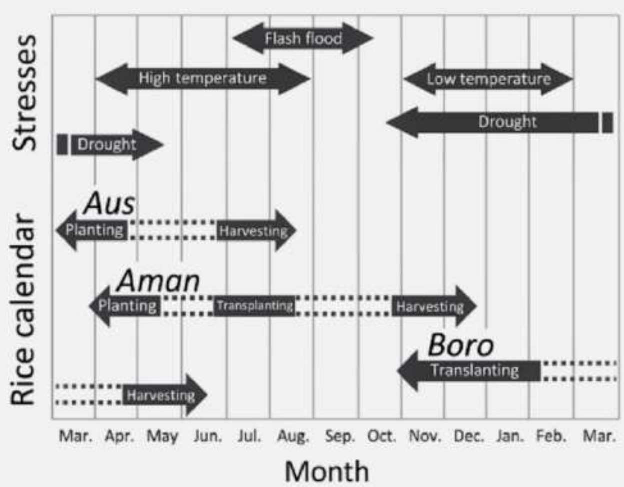
Bangladesh experiences two distinctive seasons: summer and winter. April and May are summer seasons, with maximum temperatures between 35–41°C, and the winter season is between December to February, with daily average temperatures hovering around 15–20°C and nighttime temperatures of 10–12°C. However, in the northern regions, temperatures can drop below 10°C. Bangladesh has historically recorded an average temperature of approximately 26ºC, with yearly temperature variations ranging from 15ºC to 34ºC. The country registered a peak temperature of 42.5°C in May 2014, the highest recorded temperature in sixty years. However, the red line graph in Figure 1 shows the monthly maximum temperature (°C), the yellow line shows the monthly minimum temperature (°C), and the orange line graph shows the mean temperature (°C).

Figure 01. Monthly Agroclimatic Conditions in Bangladesh



Source: World Bank Climate Change Knowledge Portal (World Bank, 2023).

Figure 02. Rice Calendar of Bangladesh



Source: Journal of International Cooperation for Agricultural Development (Shelley et al., 2016).

Rice Growing Season and Crop Calendar

Bangladesh has three distinct rice-growing seasons: Aus, Aman, and Boro. The Aus season, characterized by upland rice cultivation under rainfed conditions, precedes the monsoon season. During March and April, the Aus rice is either directly or broadcast-seeded following the pre-monsoon showers, and its harvesting takes place between July and August (Figure 2). Although some areas traditionally used for Aus cultivation have shifted to irrigated Boro rice due to the latter's high yield potential.

Aman rice, a rainfed rice variety, is the primary rice crop during the monsoon season and is widely grown, particularly in coastal regions. Aman rice cultivation occurs in two methods: direct seeding along with Aus during March and April and transplantation between July and August. The harvesting of both types takes place between November and December. However, late flooding can impact the Aman rice area, while the absence of rain during summer reduces the Aus rice growing area.

Boro rice is cultivated during the dry season, typically between December and early February. The harvesting period for Boro rice falls between April and June. Historically, Boro rice was grown in low-lying areas that retained water from the wet season. During water scarcity, manual irrigation using surface water is used (Koichi, 2011; Shelley et al., 2016). Traditionally, Boro rice was transplanted after floodwaters receded in November and harvested from April to May. However, in the 1960s, modern high-yielding rice varieties like IR-8 were introduced in Bangladesh agriculture specifically for Boro cultivation with irrigation.

Similarly, another type named IR-20 was introduced for the Aman season in 1970. Since 1973, the Bangladesh Rice Research Institute (BRRI) has collaborated with the International Rice Research Institute (IRRI) to carry out adaptive research aimed at evaluating elite genetic lines under the IRRI-managed International Network for Genetic Evaluation of Rice (INGER). BRRI has developed rice varieties such as BR and later BRRI Dhan, which are tailored to suit the agroecological conditions in Bangladesh (Hossain et al., 2013; Shelley et al., 2016). Although many IRRI lines have proven successful in Bangladesh for the Boro season, such as BR1, BR3, BR14, BRRI dhan28, and BRRI dhan29, they have not performed well in the Aman season (Shelley et al., 2016). Due to this issue, BRRI scientists crossed international elite lines with traditional landraces to create several dependable varieties, among which BR11 has become one of the most widely used.

Since the 1960s, irrigation systems have been gradually developed in Bangladesh. Low-lift pumps were used for surface-water irrigation from the mid-1960s to the mid-1970s. After this period, the use of tube wells for groundwater irrigation accelerated, and the rapid diffusion of shallow tube wells throughout the 1980s led to a significant increase in the cropped area and yield of dry-season boro rice (Koichi, 2011). With the introduction of groundwater irrigation systems and modern high-yielding varieties, dry-season boro rice became more popular, and the rice cropping pattern of Bangladesh changed significantly. Areas previously occupied by rainfed Aus shifted to boro cultivation, making boro rice the major contributor to total rice production in the country despite Aman rice having a greater coverage area (Shelley et al., 2016). In FY2022, Bangladesh produced 38.144 million MT of rice, whereas Aus 3.001 million MY (8%), Aman 14.958 million MT, and Boro 20.185 million MT (53%) (Bangladesh Bank, 2023). Bangladesh has made significant progress in maintaining good growth in rice production, and this production increase originated mainly from the shift from low-yielding traditional to high-yielding modern varieties when irrigation facilities were developed.

One contributing factor to the rise in overall rice production through the implementation of irrigation and modern rice varieties is the transformation of the rural economy. While the Green Revolution occurred in neighboring countries during the 1960s and 1970s, Bangladesh's own Green Revolution was realized during the 1980s, mainly due to the rapid proliferation of shallow tube wells for dry-season boro irrigation and modern rice varieties. The development of the rural economy, spurred by the widespread adoption of the Green Revolution, increased agricultural wages (Koichi, 2011). However, as of 2001-2002, Hossain et al. (2006) demonstrated that the coverage of modern rice varieties had only reached 65% of the total rice-cropped area (with 80% coverage during the dry season and 51% coverage during the wet season), indicating that the Green Revolution in rice cultivation has yet to materialize in Bangladesh fully (Shelley et al., 2016).

Rice Cultivars

Several institutions, including the BRRI, BINA, BAU, and other universities, are working to develop rice cultivars that have high yield potential and resistance to various biotic and abiotic stresses (Table 1).[1] The BRRI has developed 69 rice varieties, BINA has developed 17, and BAU has developed 2. While traditional rice cultivars in Bangladesh have unique qualities, such as wide adaptability, superior grain quality, and resistance to abiotic and biotic stresses, their yields are meager (less than 2.0 t/ha). They are mainly grown in less suitable areas, such as coastal areas, lands without irrigation systems, and deep-water conditions (Shelley et al., 2016). However, with the increasing population, modern high-yielding rice cultivars need to replace wide traditional varieties to meet the demand for rice.

Various irrigation systems are used in Bangladesh, such as deep-tube well, shallow-tube well, low-lift pumps, and traditional irrigation systems. Irrigation is widely practiced in Bangladesh except in areas affected by salt. Proper water management is necessary for cultivating high-yielding rice varieties in the boro season. In suitable ecological regions, 92% of farmers use irrigation, of which only 28% own irrigation equipment, while 62% buy irrigation water (Hossain et al., 2013). According to the Ministry of Agriculture, the Net Cultivable Area in Bangladesh is about 8.59 million ha. In contrast, the Total Irrigated Area is 5.59 million ha, approximately 65.08% of the Net Cultivable Area in FY2019, with 73.09% of the total irrigated area covered by groundwater and the remaining 26.91% area covered by surface water (BRRI, 2019).

However, increasing irrigated areas for rice production is limited by salinity and land elevation constraints, and farmers in salinity-affected regions prefer traditional rice varieties. The majority of farm

[1] Bangladesh Rice Research Institute (BRRI), Bangladesh Institute of Nuclear Agriculture (BINA), and the Bangladesh Agricultural University (BAU).

holdings in Bangladesh are small, but this did not impede the adoption of modern rice varieties, which were mainly hindered by logistical factors such as lack of irrigation facilities and topography affecting flood depth and soil salinity.

Factors Affecting Rice Cultivation

Various factors can impact the cultivation of rice, including climatic conditions, soil quality, water availability, pest and disease management, seed selection, and farming techniques. According to Shelley et al. (2016), various abiotic factors affect rice production in Bangladesh. For example: first, drought is a significant constraint for rice cultivation, particularly during the reproductive stage, and can cause a substantial reduction in yield. Second, depending on the rice variety, floods affect rice at different stages and can cause partial or complete crop losses. Third, salinity is a challenge in coastal areas, where traditional rice varieties are used but with poor yields. Forth, extremely low and high-temperature stresses can cause spikelet sterility and reduced yield. Fifth, soil fertility is declining due to intensive agriculture and the imbalanced use of chemical fertilizers, with N being the limiting factor. Finally, rice plants are often infested with various pests, including insects, pathogens, and weeds, which can significantly impact rice yield.

Table 01. Modern Rice Varieties of Bangladesh

Boro	*Aus*	*Aman*
BR3	BR20	BR4
BR14	BR21	**BR5**
BR16	BR24	BR10
BR17	BR26	BR11
BR18	BRRI dhan27	BR22
BR19	BRRI dhan42	BR23
BRRI dhan28	BRRI dhan43	BR25
BRRI dhan29	**BRRI dhan48**	BRRI dhan30
BRRI dhan36	BRRI dhan55	BRRI dhan31
BRRI dhan45	**BRRI dhan65**	BRRI dhan32
BRRI dhan47		**BRRI dhan33**
BRRI dhan50		BRRI dhan34
BRRI dhan55		BRRI dhan37
BRRI dhan58		BRRI dhan38
BRRI dhan59		BRRI dhan39
BRRI dhan60		BRRI dhan40
BRRI dhan61		BRRI dhan41
BRRI dhan63		BRRI dhan44
BRRI dhan64		BRRI dhan46
BRRI dhan67		BRRI dhan49
BRRI dhan68		**BRRI dhan51**
BRRI dhan69		**BRRI dhan52**
BRRI hybrid dhan2		BRRI dhan53
BRRI hybrid dhan3		BRRI dhan54
Iratom-24		**BRRI dhan56**
Binadhan-5		**BRRI dhan57**
Binadhan-6		**BRRI dhan62**
Binadhan-8		**BRRI dhan66**
Binadhan-10		BRRI hybrid dhan4
Binadhan-14		Binashail
		Binadhan-1
		Binadhan-7
		Binadhan-9
		Binadhan-11
		Binadhan-12
		Binadhan-13
		Binadhan-17
		Baudhan2

← Photo insensitive →
Binadhan-15, Binadhan-16

Salt tolerant | Submergence tolerant | Drought tolerant
Aromatic rice | Zn-enriched | Cold tolerant

Source: Journal of International Cooperation for Agricultural Development (Shelley et al., 2016)

Strategies to Overcome Problems Associated with rice cultivation

Several strategies can be employed to overcome challenges in rice cultivation, including improving irrigation and drainage systems, using high-quality seeds, implementing integrated pest and disease management practices, adopting sustainable farming techniques, and conducting regular monitoring and evaluation of crop performance. However, Shelley et al. (2016) discuss strategies to overcome problems associated with rice cultivation in Bangladesh. These strategies include improving crop management practices such as using quality seeds, balanced fertilizers, and controlling weeds and pests. Besides, they have emphasized incorporating water-saving technologies such as alternate wet and dry irrigation methods and surface water management. Additionally, they have suggested combining genetic approaches to improve rice cultivars and recommend using organic and inorganic fertilizers in a balanced manner. Finally, they have discussed the need for improved post-harvest technology and the challenges small farmers face in accessing quality seeds.

Conclusion

To conclude, despite achieving self-sufficiency in rice production, Bangladesh's current yield levels remain low. Therefore, the country has the potential to increase its rice production and export capacity, which would positively impact the national economy. To achieve this, targeted breeding programs are essential to develop rice varieties that can adapt to the diverse environments found in Bangladesh. Such efforts should focus on developing high-yielding, early-maturing, drought-resistant, salt-tolerant, disease-resistant, submergence-resistant, cold-tolerant, high-temperature-tolerant, and nutrient-rich varieties. Furthermore, adopting proper crop management strategies will also play a crucial role in enhancing rice production.

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