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A B S T R A C T

Rice is a basic food item for human consumption cereal that is extensively cultivated in different parts of Dinajpur and Lalmonirhat districts. It is widely cultivated traditional indigenous rice varieties by the local cultivars in the near past. This study presents a synoptic history of rice production experiences of these localities. It highlights the types of rice planted in the area and the changing patterns of rice production amongst the people for their food security. It also examines the challenges confronting rice production in Dinajpur and Lalmonirhat districts. The evolution of indigenous rice cultivation and change the rice cultivation from indigenous rice to high-yielding varieties (HYV's) was discussed in the study. Such problems as food security, change of environmental condition, especially drought, flood, and lack of new technical knowledge are highlighted as challenges to cultivate the indigenous rice verities. Though the adoption of modern irrigation strategies by agricultural extension as a way of improving food security in these regions, and it is required to conserve the indigenous rice, and traditional knowledge that it can be used with modern technology-based agriculture to cope-up with climatic hazards.

***Key words*:** Indigenous rice varieties, HYV's, Food security, Environmental change, Conserve

Rice (*Oryza sativa* L.) is an important food of Asia, including India and Bangladesh, is feeding more than 3 billion people [1]. Rice plays a unique role in providing food to the majority of the world population [2]. The green revolution is considered to improve the production of food grains in our country, and its role in achieving the status of self-sufficiency in food grain is beyond any doubt [3]. The high-yielding varieties are the backbone of the green revolution, which indirectly stimulated the erosion of the indigenous and wild rice varieties. Now-a-day over 70% of rice cultivation is being done using high yielding variety (HYV) [4-5]. Bangladesh is the 3rd world's largest rice producer, and rice accounts for 50% of the agricultural GDP of this country [6]. The quality of the rice grains may be considered as the viewpoint of size, shape, and appearance of grain, milling quality, and cooking properties [7-8]. The breeders and nutritionists seek rice grains with higher content of protein, vitamins, and minerals. The cultivated rice initiated in South East Asia in the wet tropical climate and below control of the local environment and farmer's needs have evolved into 88,681 various rice varieties out of that 55,615 are landraces, 1,171 are wild races, and 32,895 are other varieties. Bangladesh has a stock of more than 8,000 rice germplasms of which nearly 100 are aromatic varieties [9]. But due to new agricultural technology for more production, the demands of these traditional varieties have become less [10]. The farmers often adopt modern rice varieties and no longer grow the traditional rice varieties they had been using for generations. Eventually, many of these genetic varieties are lost forever. Lalmonirhat and Dinajpur districts are rich in rice diversity. Farmers of this region cultivated different rice varieties but there is every possibility for genetic erosion of rice due to the introduction of new agricultural technology and the quick economy as well as the availability of several high-yielding varieties in the market. Due to quick population expansion and increasing demand for food as well a decrease in the agricultural area has significantly influenced yields of high-yielding varieties than traditional varieties. The farmers still grow some landraces rice varieties, which do not only suit their flavor but also provide food safety. Bangladesh is also the home to many locally adapted aromatic and quality rice landraces. Despite their low-yield potential, these landraces are grown for their high market and social values. Aromatic rice in Bangladesh generally has short bold and medium bold grain types with mild to strong aroma [11-12]. A considerable number of aromatic rice landraces, namely Chinigura, Kalijira, Kataribhog, and Begun Bichi are grown in the different districts of Bangladesh. From these aromatic rice varieties, Chinigura is the principal one that covers over 70% of rice cultivations in the northern

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districts of Dinajpur and Naogaon. Other important aromatic rice varieties are Kalijira and Kataribhog are mainly cultivated in Mymensingh and Dinajpur districts [13]. The districts under consideration here have fertile land and good agriculture practices. At this moment it is required to conserve the traditional indigenous rice varieties and traditional knowledge that it can be used with modern technology-based agriculture to cope up with climatic hazards and environmental pollution as well as to give support to marginal farmers. The main objective of this paper is to find out the realization and impact of Stress Tolerant Rice in the Lalmonirhat and Dinajpur districts of Rangpur Division, Bangladesh. All the data for this paper have been collected from local cultivars in Lalmonirhat and Dinajpur districts, reports, books, and the internet.

MATERIALS AND METHODS

An extensive survey was done in Dinajpur and Lalmonirhat district in Bangladesh to collect data on the indigenous rice varieties are cultivated in the near past. The information was recorded from the local farmers of Dinajpur and Lalmonirhat districts on the salient features of the indigenous rice varieties. The study was conducted by adopting qualitative methods of data collection and analysis. A field study was done on the total number of 100 cultivators from these localities to get knowledge about different rice varieties cultivated by them, their local name, and their uses. The literature review, field visits were done for the data collection of various indigenous rice varieties.

Lalmonirhat district is located in between 25°46' to 26°33' north latitudes and in between 89°01' to 89'36' east longitudes. It is boarded by West Bengal, India to the north, Rangpur district to the south, Korigram district and West Bengal to the east, and Nilfamari and Rangpur districts to the west. Dinajpur is located between latitudes 25°10' to 26°04'N and longitudes 88°23' to 89°18'E. It is bounded by Thakurgoan and Panchagarh districts on the north, Gaibandha and Jaipurhat districts on the south, Nilphamari and Rangpur districts on the east, and therefore the West Bengal state of India on the west. Location of the survey area is shown in (Fig 1). Lalmonirhat district belongs to mainly the Tista Meander Floodplain area; On the other hand, Dhepa, Punarbhaba, and Atrai are the main rivers of Dinajpur districts [14-15]. Lalmonirhat district is flooding when the Tista overflows its banks leaving local communities without land, housing, sanitation, or any assets to make normal living continue [14]. The ecosystems of Dhepa, Punarbhaba, and Atrai River are not very encouraging. Some parts of these rivers are completely dried up during the winter and floods in the rainy season [15]. Due to population growth and increased demand for food, farmers need to adopt new agricultural techniques for mass production using high-yielding varieties. These eventually reduced the practice of cultivating traditional landraces varieties. The cultivation of some indigenous rice varieties has declined so that if care is not taken or conserved in time, they will be lost forever. In this context, we would like to conduct a study to know the diversity of rice in different parts of the Dinajpur and Lalmonirhat districts. If the effects of new agricultural technologies using high-yielding varieties are causes genetic decay and treated immediately. It is necessary to be aware of the farmers about this and encouraged them to cultivate the traditional rice varieties too alongside these high-yielding varieties.

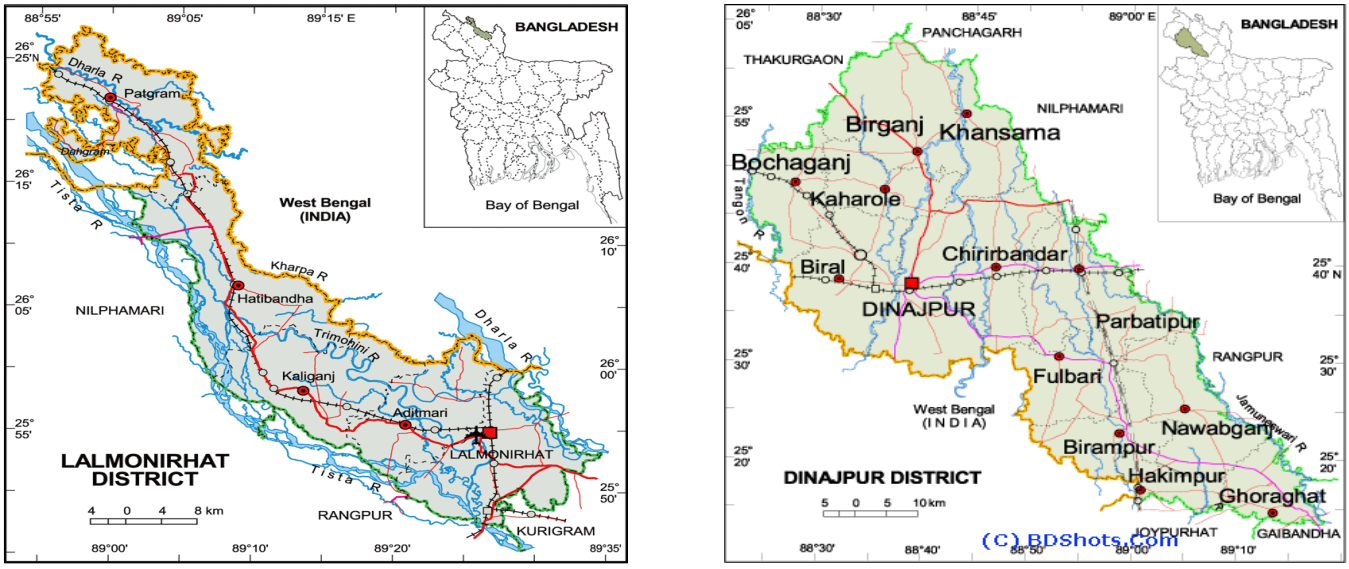

Fig 1 Location of the survey area

RESULTS AND DISCUSSION

The different high-yielding rice varieties are cultivated in different localities of the Lalmonirhat and Dinajpur districts. But the common indigenous rice varieties are Chinigura, Kalojeera, Radhunipagol, Kalonunia, Bhog, Kataribhog, and Begun Bichi cultivated for commercial purposes. Though the cultivation of this different indigenous rice has decreased, it is shown that some varieties are still cultivation in a marginal stage (Table 1). Some common indigenous rice varieties were cultivated by the farmers of these districts in the near past is given in (Table 1). The size and shape of rice varieties are presented in (Table 1, Fig 2-3). The quality of rice grains largely depends on the physical properties which are greatly influenced by the genotype and grain colors [16], although the grain quality does not reflect the nutritional quality of rice. The grain colors of these rice varieties are presented in (Table 1, Fig 5). Size and shape are important parameters of rice grain quality; consumers have preferences for the size and shape of the rice-based on the cooked rice texture. Consumer preference varies differently from variety to variety. The size and shape are considered to be the first important criteria for the development of a new variety for commercial production. In this survey, rice grains variations were observed among the rice varieties. Rice varieties are categorized as long, medium, and short in size by the farmer's recommendation. Rice varieties also categorize as

slender, round, or bold by the farmer's recommendation. Based on grain size the rice is divided into three basic types as long-grain, medium-grain, and short-grain. Long grain rice is flexible and accepted worldwide [17]. The study adds a new feature confining itself to the northern part of Bangladesh. The importance of these varieties is massive keeping their gene pool in mind. At present when much stress is being laid on the conservation of landraces rice varieties, we cannot afford to lose landraces of rice varieties. Another important issue is sustainable agriculture in the present situation where climate change is adversely affecting agricultural productivity. Local indigenous rice varieties, which have been sustained in particular climatic conditions since thousands of years back are better suited as compared to the high-yielding varieties. The local indigenous rice varieties cultivated in Lalmonirhat and Dinajpur districts are shown in (Table 1, Fig 4).

Table 1 Some landraces rice varieties cultivated by the farmers of Lalmonirhat and Dinajpur districts in near past

S. No.	Rice varieties	Colour of the grain	Size of the grain	Shape of the grain	Cultivation area	Uses and cultivation purpose
1	Aijone	White	Short	Slender	Lalmonirhat	Extinct
2	Akshisa	White	Long	Slender	Dinajpur	-
3	Agurshail	Red	Long	Bold	Dinajpur	Little cultivated
4	AughanDhape	White	Medium	Bold	Dinajpur	Extinct
5	Badam Soru	White	Short	Slender	Both District	Little cultivated
6	Badshabhog	White	Long	Slender	Both District	Fine aromatic
7	Baoijhaki	Brown	Short	Round	Both District	Extinct
8	Baoibhog		Short	Medium	Lalmonirhat	-
9	Bashikalam	White	Long	Slender	Both District	Little cultivated
10	Bari Bangla	White	Long	Bold	Dinajpur	Little cultivated
11	Bateo	Brown	Long	Bold	Both District	Little cultivated
12	BegunBichi	White	Short	Slender	Both District	Little cultivated
13	Bhadoi	Red	Medium	Bold	Both District	Extinct
14	Bhog Dhan	White	Medium	Slender	Both District	Commercially cultivated
15	Bhaturi	White	Medium	Bold	Dinajpur	-
16	Bittri	White	Medium	Bold	Both District	Little cultivated
17	Binni	White	Long	Bold	Both District	Little cultivated
18	Binnaphul	Black	Short	Round	Both District	Aromatic
19	Bochi	White	Short	Bold	Both District	Extinct
20	Bukdhosha	White	Medium	Slender	Dinajpur	-
21	Chatur	White	Long	Bold	Dinajpur	Extinct
22	Chandanboro	White	Long	Bold	Dinajpur	No more data
23	Chinigura	White	Medium	Slender	Both District	Commercially Cultivated
24	Chinikanai	White	Short	Slender	Lalmonirhat	Aromatic
25	Chinikanai-2	White	Short	Bold	Dinajpur	Lightly scented (Islam *et al*. 2016)
26	Dubraj	Red	Very Long	Bold	Lalmonirhat	Little cultivated
27	Dudh Kalam	White	Long	Slender	Both District	Little cultivated
28	Desikatri	White	Short	Slender	Both District	Little cultivated, (Islam *et al*. 2016)
29	Dhan chikon	White	Medium	Slender	Both District	Little cultivated
30	Dumraha	Red	Medium	Bold	Lalmonirhat	Little cultivated
31	Ful Papri	White	Medium	Bold	Lalmonirhat	Extinct
32	Ganjia (Soru)	Brown	Short	Slender	Both District	Commercially cultivated
33	Goria (Black)	Black	Medium	Bold	Both District	Extinct
34	Goddi	White	Short	Bold	Lalmonirhat	Extinct
35	Gotadhumra	White	Medium	Bold	Lalmonirhat	-
36	Haldidam	White	Long	Slender	Both District	Extinct
37	Haldijauwn	Yellow	Long	Bold	Lalmonirhat	Extinct
38	Indurshail	White	Medium	Round	Both District	Little cultivated
39	Jashoa	Red	Short	Round	Both District	Little cultivated
40	Jirakatri	White	Very Long	Slender	Dinajpur	Commercially Cultivated
41	Jirashail	White	Medium	Slender	Dinajpur	Aromatic, commercially cultivated, online
42	Jirabhog		Short	Bold	Dinajpur	(Islam *et al*. 2016)
43	Joldhepa	White	Long	Bold	Lalmonirhat	Extinct
44	Jamrosh	Red	Short	Slender	Dinajpur	No more data
45	Kataribhog	White	Short	Slender	Both District	Commercially Cultivated (Islam et al., 2016)
46	Kalabinni	Black	Medium	Slender	Lalmonirhat	Little cultivated
47	Kalojeera	Black	Medium	Slender	Both District	Commercially Cultivated
48	Kalomanik	Black	Long	Slender	Both District	Drought tolerant, Commercially cultivated
49	Kalonunia	Black	Long	Slender	Dinajpur	Delicious, Insect tolerant
50	Kashiabinni	Red	Medium	Slender	Both District	Little cultivated
51	Kanchandhan	White	Medium	Slender	Both District	Extinct

52	Kalam	White	Long	Slender	Both District	Little Cultivated
53	Koladama	Red	Long	Slender	Both District	Little cultivated
54	Koldoma	Red	Long	Bold	Dinajpur	Little cultivated
55	Kalo Dhopa	Black	Medium	Bold	Both District	Little cultivated, Extinct
56	Kalobhog	Black	Short	slender	Lalmonirhat	Scented
57	Khaiwan	Red	Long	Bold	Dinajpur	Extinct
58	LalDhepa	Brown	Long	Bold	Both District	Extinct
59	Lal Soru	Red	Short	Slender	Both District	Little cultivated, (Islam et al., 2016)
60	Malshira	Red	Short	Slender	Both District	Little cultivated
61	Mukta	White	Medium	Slender	Dinajpur	HYV's, Little cultivated
62	Najirshail	White	Long	Slender	Both District	Aromatic, Commercially cultivated, online
63	Natachuka	Brown	Medium	Slender	Dinajpur	Extinct
64	Niroji	Yellow	Medium	Bold	Both District	Extinct
65	NoaJung	Red	Long	Bold	Both District	Aromatic, Extinct
66	Paijam	White	Short	Slender	Both District	Little cultivated
67	Panati	White	Long	Slender	Lalmonirhat	Little cultivated
68	Panishail	White	Long	Bold	Dinajpur	Flood tolerance
69	Patharnutti	White	Short	Bold	Both District	Extinct
70	Phulpakhri	Brown	Medium	Bold	Lalmonirhat	Delicious recipes
71	Pokhikhowa	White	Medium	Slender	Dinajpur	Extinct
72	Sadadhepa	White	Medium	Round	Both District	Extinct
73	Sadadhumra	White	Medium	Bold	Both District	Extinct
74	Saitondumur	Red	Short	Bold	Dinajpur	Extinct
75	Sapahar	Red	Short	Bold	Both District	-
76	Soru gangia	Red	Short	Slender	Both District	Little cultivated
77	Soru malshira	Brown	Short	Slender	Both District	Little cultivated
78	Shilkomar	White	Medium	Bold	Lalmonirhat	Extinct
79	Uzzal	White	Medium	Slender	Dinajpur	Extinct
80	Voughdhan	Black	Medium	Slender	Both District	Commercially cultivated
81	Vishnubhog	White	Very Long	Bold	Dinajpur	Little cultivated

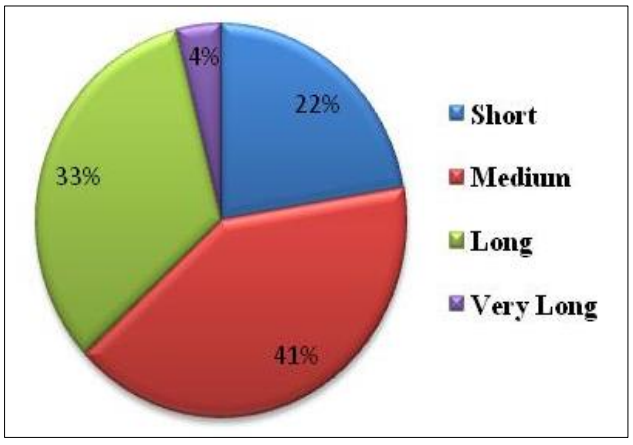

Fig 2 Size of the rice grain

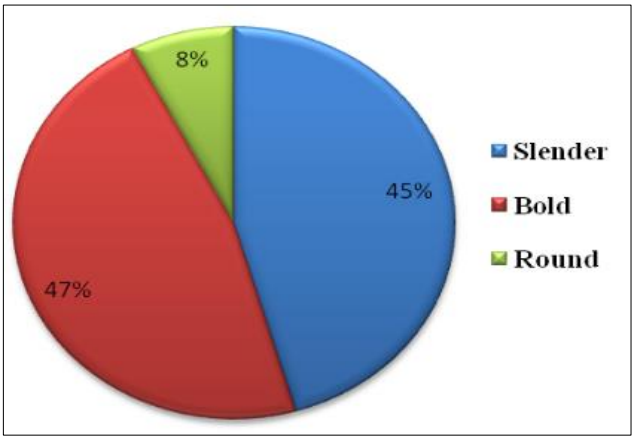

Fig 3 Shape of the rice grain

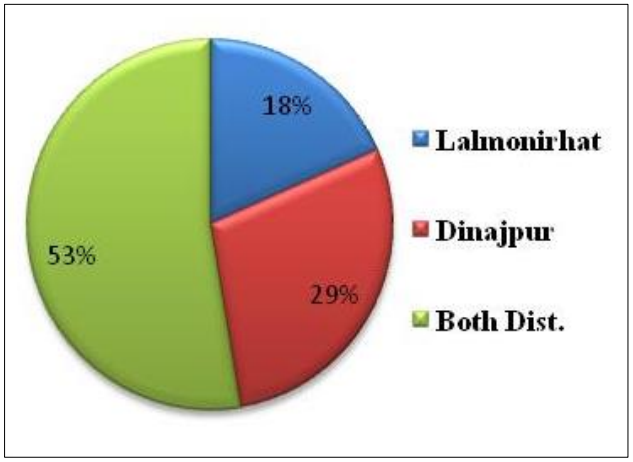

Fig 4 Cultivation area of this varieties

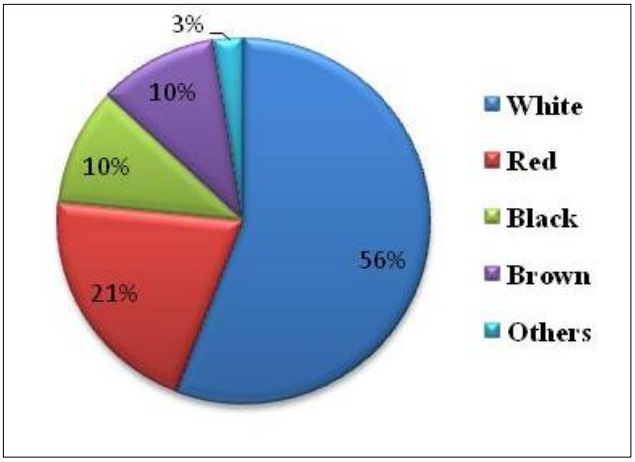

Fig 5 Colour of the rice grain

Importance of indigenous rice cultivation

Aromatic indigenous rice varieties are a good source of different phytochemicals such as phenolic compounds, anthocyanin, and flavonoids. These components are likely to be concerned with the reduction of human degenerative diseases due to their antioxidant properties and free radical scavenging properties [18]. Phyto-chemicals in the aromatic rice grains have recently been ascribed to positive nutritional properties, promote human health by reducing the concentration of reactive oxygen species, and prevention of cardiovascular diseases and cancer [19-20]. The significance of the economy of any crop indicates its market price value as well as the input and output cost difference. From this view, the cultivation of that crop is economically significant which may provide maximum profit than others [21]. Some rice varieties can tolerate the scarcity of water. This was confirmed by the economic analysis of rice cultivation under alternate irrigation, where other high-water-demanding crops are cultivated [22]. The cost of cropping indigenous rice varieties is less than HYV's (High yielding variety) as they consume less fertilizer and pesticides but their production is low. So, these are suitable for green and organic farming. The quality and the nutritional values of these rice should be judged to give the scientific background of its consumption and thus to give a good market value. These will encourage the marginal farmers to cultivate these thus it will be preserved as well as reduce the environmental hazards. The financial importance and consumer requirements for aromatic rice in the Indian subcontinent from ancient times [21]. From ancient times various types of indigenous rice used in Ayurvedic treatises, aroma as an important property of scented rice, and state-wise distribution of various scented rice varieties in India [21]. According to Mannan *et al*. [23], international standards, history, and recent development of traditional and advanced aromatic rice varieties, namely long slender basmati rice varieties demand is increasing. This initiative was launched to bring back the aromatic varieties of rice using natural methods. In the present context of sustainable and intensive sustainable development, it is important to practice the cultivation of rice in such a manner that the use of chemical fertilizers, chemical pesticides may be reduced and the crop should tolerant to climatic hazards. But another issue is that the production of rice should be increased to meet the increasing demand. So it is not possible to the drastic reduction of cultivation of a high yielding variety of rice but it is of emergent importance to restore the indigenous varieties and improve their quality and production.

Ecological importance of indigenous rice cultivation

Traditional rice varieties have an aroma and contain huge diversity in grain shape, size, color, and nutritive values of some varieties also contain micronutrients like iron and zinc [24]. The ecological significance of the cultivation of indigenous aromatic rice thus incorporates the relationship between the indigenous aromatic rice with other crops and also with their physical surroundings. Colored rice contains antioxidant properties which good for human health [25]. Red rice varieties have high medicinal value and use as a functional food [26]. The micronutrients are Copper, Iron, Manganese, and Zinc are accumulating in grains and an important to grain quality [27-28]. Micronutrients also played a vital role in cellular and hormonal responses, signaling, and functions [29-30]. Local rice varieties, in general, require low inputs of fertilizers and pesticides, adaptive to environmental problems, grain prices are more expensive, its cultivation is easy, and for farmers considered more efficient [31]. Relatively local rice varieties are tolerant of iron toxicity and this rice contains high levels of Fe and Zn [32]. Cultivation of local indigenous rice varieties such as returning organic matter to the soil means they can maintain soil fertility, which is related to environmental integrity within the framework of agricultural sustainability [33].

The market value of indigenous rice varieties

Farmers still cultivated traditional color rice varieties widely because they will be grown under low inputs and produce an inexpensive yield under the seasonal environmental conditions to which modern rice varieties are not adapted [26]. Fine aromatic rice varieties are of high commercial importance with economic benefit [26]. Bangladeshi aromatic rice is expected to have a good market demand in the international context for its fine aroma and grain quality [26, 34]. It is shown that net economic returns of the Kalijira were substantially positive, and thus the varieties had a fair chance of finding a good export market [34, 35]. Among the aromatic rice varieties, Kalijira and Kataribhoge is the most popular local rice variety grown in the Dinajpur region. Due to its geographical and ecological advantages, the Dinajpur region is highly concentrated in the cultivation of various aromatic rice varieties [35]. Though the yields of aromatic cultivars were much lower compared to other non-aromatic cultivars, lower production costs and better prices made the cultivars somewhat rewarding compared to other rice cultivars [34]. Islam et al., [36], noted that aromatic rice had a low yield but a high price and low cultivation cost and generated higher profit to compare the other rice varieties.

Challenge of indigenous rice cultivation

Population density and depleted natural resources (cultivable land) are increasing the pressure on agriculture systems in Bangladesh [37]. Due to the increase and construction of houses, roads, industries, factories, and highways, the cultivable land is decreasing. On the other hand, due to urbanization, food habits tend to change, demanding the cultivation of new crops that must share land used for rice cultivation [38]. Due to changes in the global climatic condition, agriculture is facing different problems, like drought, flood, salinity, heat stress, and low soil fertility. Global warming may threaten food security in India and Bangladesh [39]. In Bangladesh, located in the lowest part of the Gangetic Brahmaputra basin, Mola [40], showed that rice production and yield are closely related to fluctuations in annual rainfall. In Bangladesh, approximately 4% annual loss of rice production for flood, and the highest proportional loss was almost 14% in the severe flood year of 1988 [41]. Local rice varieties are more tolerant to the various land conditions [42]. Though local rice varieties are low yield potential, it requires low inputs of fertilizers and pesticides, adaptive to environmental problems, grain prices are more than high HYV's, its cultivation is easier, and for farmers considered more efficient [31]. Besides, the local landraces rice varieties are relatively tolerant of iron toxicity and rice contains high levels of iron and zinc [31-32].

Climate change accelerated the intensity of drought; normally the north-western part of Bangladesh encounters more droughts than the other parts of the country [43-44]. This has an enormous impact on crop production as the production of all winter crops goes down with the arrival of droughts [43]. Drought is also associated with land degradation, low livestock numbers, unemployment, and malnutrition [45]. Drought can affect rice cultivation, more than 80 percent of the total cultivated area in Bangladesh, and an average 50% production reduction of the crop worldwide [46-48]. The flood-affected rice cultivation area and rice production show a significantly

negative correlation [39]. Floods affect the rain-fed lowland rice areas, mainly at the seedling stage. Heavy rainfall and flood causes damage at the seedling stage and also delay planting [49-51]. A decrease in rice yield due to insects, pests, and various diseases has been recorded by about 31.5% in Asia [52, 53]. More than 800 rice insect species are found in the world's ecosystems, and only about 100 species attack rice [53].

Multiple stresses are prevalent in rice cultivation in Bangladesh. Bangladeshi farmers run through year-round farming, frequently limiting land available for the timely planting of the next crop. The concentration of different salts such as NaCl, $CaCO_3$, $MgCO_3$, $MgSO_4$, and $CaSO_4$ in the soil or water is resulting in high is refers to salinity [54-55].

CONCLUSION

Due to rapid population growth and increasing demand for food as well as a decrease in the agricultural and cultivation area of Dinajpur and Lalmonirhat district is largely influenced by the high-yielding varieties rather than traditional rice varieties. For the point of rice biodiversity, there are 81 different traditional rice varieties cultivated in these localities is the resource for future rice cultivation. So, it is the proper time to be aware of the farmers about the importance of these rice varieties. So, we should encourage the farmers to the cultivation of these traditional varieties too along with different high yielding varieties.

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