



Minor Cereal Crops Production and their Future Prospects in Bangladesh

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Authors' contributions

This work was carried out in collaboration among all authors. Authors JCB and MMH performed the statistical analysis and wrote the protocol and wrote the first draft of the manuscript. Authors MRI and AH managed the analyses of the study. Authors JCB and MMH managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Different kinds of cereals are the dominant carbohydrate source for the global population of which minor cereals, a group of neglected crops, play an important role in providing substitute of rice or wheat in the harsh environment of the globe. These crops have been replaced in many areas with the advent of irrigation facilities, availability of modern crop varieties and improvement of fertilizer management systems. In the present investigation, we have delineated production zones and established relationships of minor cereal cultivation with selected social character and future climatic conditions based on existing literature and survey data. In most cases, six minor cereals are cultivated in Bangladesh. *Panicum miliaceum* and *Setaria italic* cover larger areas and are mainly grown in north, north-west, central parts and hilly regions of the country and provide 400-1500 kg ha⁻¹ grain yield. Although low grain yields, farmers having 0.2-0.8 ha land holdings mostly cultivate minor cereals because of its high profit within a short period of time, can be grown in poor soil and does not require special care. Besides, the product can be utilized in different ways, such as food and feed with social aristocracy. Because of climate change impacts, the optimum temperature

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windows for studying minor cereals will be narrowed down to 15 November through 15 February by 2050 although the critical maximum temperature range might not be a problem for growing minor cereals in Bangladesh. If high-yielding varieties of minor cereals are available, it would be a climate-smart technology in the future.

Keywords: *Panicum miliaceum*; *Setaria italic*; area coverage; yield; climate change.

1. INTRODUCTION

Global population is increasing including Bangladesh and thus the demand for cereal is also increasing [1] but a cultivable area in Bangladesh is decreasing [2]. Moreover, the production of cereals is decreasing in many areas because of climate change (CC) impacts [3]. Soil productivity is declining with continuous chemical fertilizers use [4] along with decreased freshwater availability for agricultural production and thus a challenge of sustainable crop production [5]. It is estimated that agricultural systems in the world are losing about 75 billion tons of fertile soils each year [6]. Under such situations, it is the responsibility of the scientific community to look for alternate avenues that can help in maintaining food security as well as reducing greenhouse gas (GHG) emissions from agricultural soils. Minor cereals such as proso, pearl, finger, kodo and foxtail can play an important role in food and nutrition security around the globe [7]. Millets release less GHG in the range of 3218-3358 kg CO₂ eq. ha⁻¹ [8,9].

Minor cereals, the neglected crops too, can be cultivated under water and nutrient stress conditions. They can be cultivated in semi-arid and arid regions [10,11]. Some of them, such as millets, are thermophilic indicating that minor cereals could be one of the weapons for combating CC impacts. Pearl millet can grow on poor sandy soils and is easily more adaptable to dry climates than sorghum and maize making it sixth most important cereal in the world, especially for Africa, India and Pakistan [10, 11]. Finger millet (*Eleusine coracana* L.) stands sixth position in India after wheat, rice, maize, sorghum and bajra [12]. This crop withstands salinity, high temperature, variable soil pH (5.0-8.2) and medium rainfall [13]. Almost similar environments prevail in south-west and north-west regions of Bangladesh indicating the suitability of finger millet cultivation.

Water and food crises are emerging globally and thus people are suffering from malnutrition. Millets as C₄ crop having the capacity to fix

carbon even under high temperature and low nitrogen conditions [14,15], it can play an important role in food and nutritional security [12]. Millets are easily digestible, non-allergic and release lower volume of glucose, thus making it safer for consumption by diabetic patients [16]. Moreover, they are rich in calcium, phosphorus, potassium and iron [9]. Such qualities are highly desirable for nutritional security in Bangladesh. Some farmers grow minor cereals in Bangladesh under diverse ecological conditions and under unfavorable ecosystems. We hypothesize that millets would be playing a vital role in future agriculture under a changing climate in Bangladesh, which was tested in the present investigation along with delineation of production zones, establishing relationships of minor cereal cultivation with selected social character and climatic conditions.

2. MATERIALS AND METHODS

Data were collected from the Bangladesh Bureau of Statistics [17,18], Bangladesh Agricultural Research Council (<http://www.barc.gov.bd/>) and own survey. A total of 4945 mauzas/mahallas (the smallest administrative unit) were considered in the first stage and then 143980 households (HHs) were selected for data collection. A pre-tested questionnaire was used in seven districts followed by necessary modifications for final data collection [19]. Area coverages and grain yields of Cheena or common millet (*Panicum miliaceum* L.), Kaon or pearl millet (*Setaria italica* [L.], Beauv), Bajra (*Pennisetum glaucum* [L.] R. Br), Barley (*Hordeum vulgare* L.), Oat (*Avena sativa* L.) and Jower (*Sorghum bicolor* [L.] Moench) were collected. For own data collection, we have first selected two districts where minor cereals are grown by the farmers followed by selection of HH who are involved with such activities. Nine hundred farmers from Munshiganj and Tangail districts were interviewed from November 2018 to March 2019 through pre-tested structured questionnaire for finding out the responses on (i) why they grow minor cereals, (ii) how the crops are utilized and (iii) what is the future of minor

cereals under changing climate? Optimum and lethal temperatures for minor cereals were established according to [20,21]. As climate change impacts are visible in terms of temperature rise in different parts of the country, future climate change scenarios were considered as established by Biswas et al. [22]. It was found that temperature rise could be 1-4°C depending on the models used and regions of the country. However, only representative concentrated pathways (RCP) 6.0 and 8.5 were considered because temperature rise is likely to be more in the future than predicted in RCP2.6 and RCP4.5. Graphs were prepared using Excel software. Spatial distribution maps on area coverages and yield levels were prepared using IDRISI.3.2. Land area coverages by the minor cereals were considered for the determination of major or minor areas. The highest area covered by a crop represented major group followed by others. Social status in terms of land holdings, education and age were evaluated along with ways and means of minor cereal cultivation and uses were delineated.

3. RESULTS

3.1 Area Coverage and Yield

Minor cereals mostly grow in north, north-west, central parts (nearby big rivers) and hilly areas of the country (Fig. 1). Area coverage in the range of 10-50 ha was the highest (23.09%), followed

by 11.46%. Grain yield varied from <400 kg ha⁻¹ (6.04%) to >2000 kg ha⁻¹ (2.86%) in which major areas (36.63%) produced 400-1200 kg ha⁻¹ yield (Fig. 2). Plot size for *P. miliaceum* and *S. italica* cultivation was mostly 10-20 ha that covered about 15.50%, followed by 5-10 ha in about 8.92% areas in minor cereal production zones in the country (Fig. 3) and grain yield varied from <650 kg ha⁻¹ to >1500 kg ha⁻¹ (Fig. 4). In major areas (21.97%), grain yields of *P. miliaceum* and *S. italica* were 650-1000 kg ha⁻¹ followed by 1000-1500 kg ha⁻¹ in about 14.39% areas.

3.2 Social Status of Farmers and Minor Cereal Cultivation

We have investigated the reasons for growing millets in Bangladesh based on selected areas. Most of the farmers cultivate different minor cereals because of its high profit within a short period of time, can be grown in poor soil and does not require special care. The product can be utilized in different ways, such as food and feed with the social aristocracy (Table 1). Some of the farmers (about 40%) believe that these are the potential crops for the future. The area coverage for minor cereal production by the most farmers (about 43% of the respondent) was in the category of 0.2-0.8 ha followed by 0.05-0.2 ha and 1.0-2.0 ha, respectively (Table 2). Their education level was mainly up to class 5 in about 58.89% cases and the dominant age group was 40-50 years.

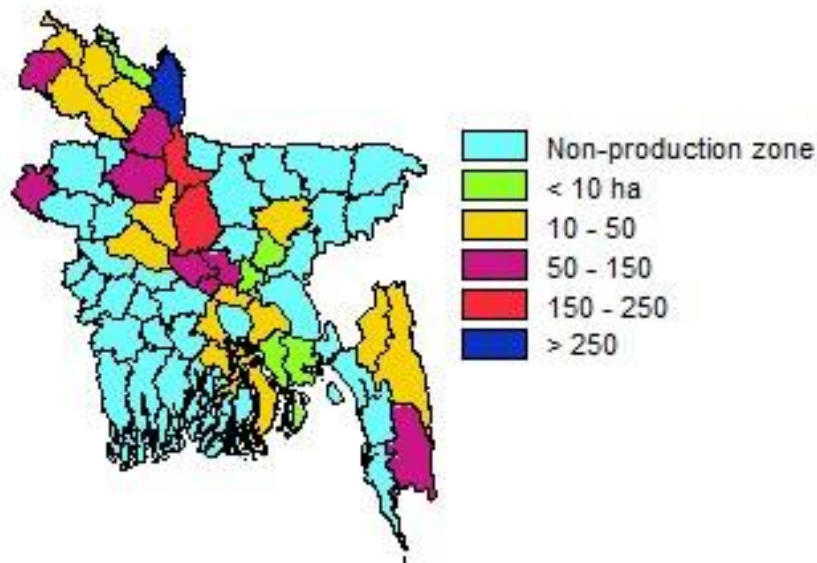


Fig. 1. Area coverages by minor cereals in Bangladesh

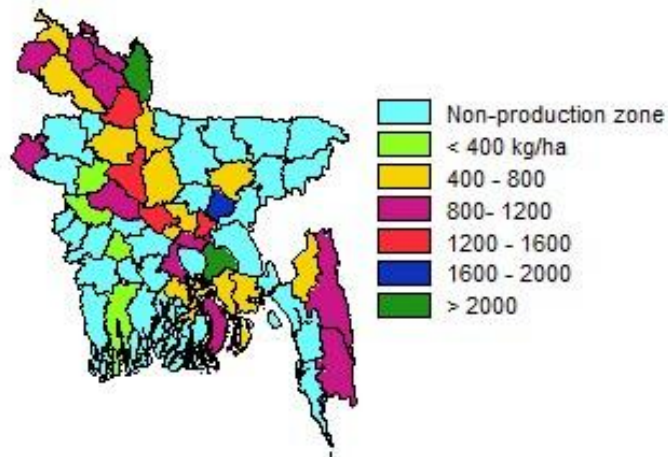


Fig. 2. Yield levels of minor cereals in Bangladesh

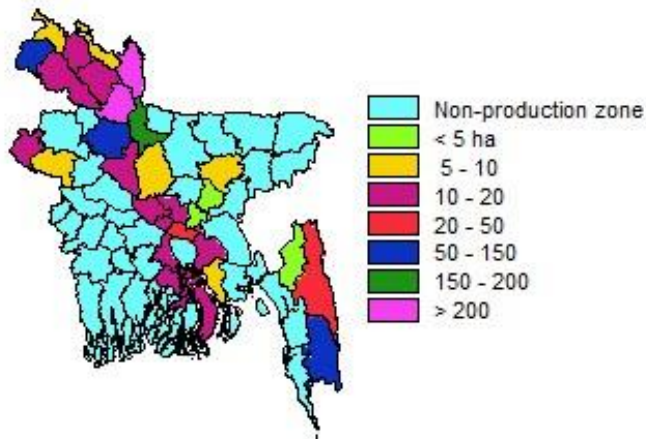


Fig. 3. Area coverage by *Panicum miliaceum* L. and *Setaria italica* (L) Beauv in Bangladesh

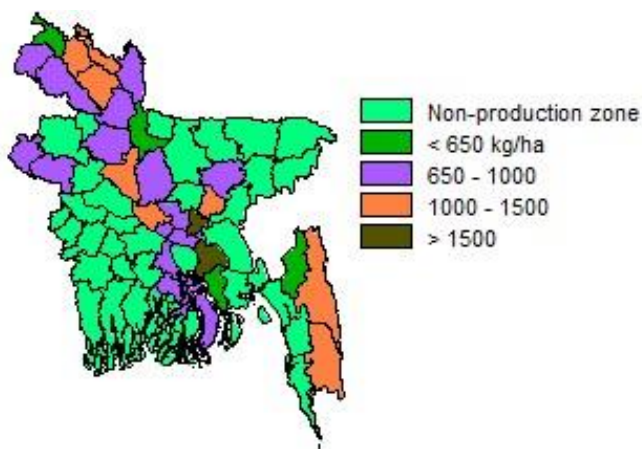


Fig. 4. Grain yield of *Panicum miliaceum* L. and *Setaria italica* (L) Beauv in Bangladesh

Table 1. Reasons in brief for cultivation of minor cereals in Bangladesh

Items	Reasons
Market price	High market value, profitable crop in a short time
Cultural management	Can be grown as mixed crop, suitable in sandy loam soils, no irrigation water required, no special care needed, less affected by insect pest and diseases
Uses	As cake, delicacy as payes (sweet product with milk), cereal food, moa (fried sweet ball of millet), bakery industry, feed of chicken and animals, substitute of rice and wheat, use of current fallow land
Yield	Poor yield, many farmers are not interested to cultivate
Others	Potential crop for the future

Table 2. Area coverage and farmer's age and education levels in Munshiganj district

Land coverage		Education level		Age group	
Area (ha)	% of farmers	Class	% of farmers	Age (yr)	% of farmers
<0.05	7.78	<1.0	2.22	<30	2.22
0.05-0.2	16.67	1.0-5.0	58.89	30-40	28.33
0.2-0.8	42.78	5.0-8.0	31.11	40-50	41.67
0.8-1.0	11.11	8.0-12.0	6.67	50-60	25.00
1.0-2.0	12.78	>12.0	1.11	>60	2.78
2.0-3.0	5.56				
>3.0	3.33				

3.3 Temperature Vulnerability and Minor Cereals

In 2010, minimum temperature was not a problem for minor cereal production; but the window of optimum temperature for sorghum and finger millet growth and development existed from November to February (Fig. 5a). Critical maximum temperatures for pearl millet, finger millet and sorghum were not observed during winter season. However, optimum temperature windows for studying minor cereals will be narrowed down to 15 November through 15

February during 2050 (Fig. 5b). Based on this, in future, the critical maximum temperature range might not be a problem for growing minor cereals in Bangladesh.

4. DISCUSSION

Spatial distribution of minor cereals in Bangladesh is mostly seen around the mighty rivers except hilly regions of the country. Special features of those areas are soil erosion and siltation and in most cases,

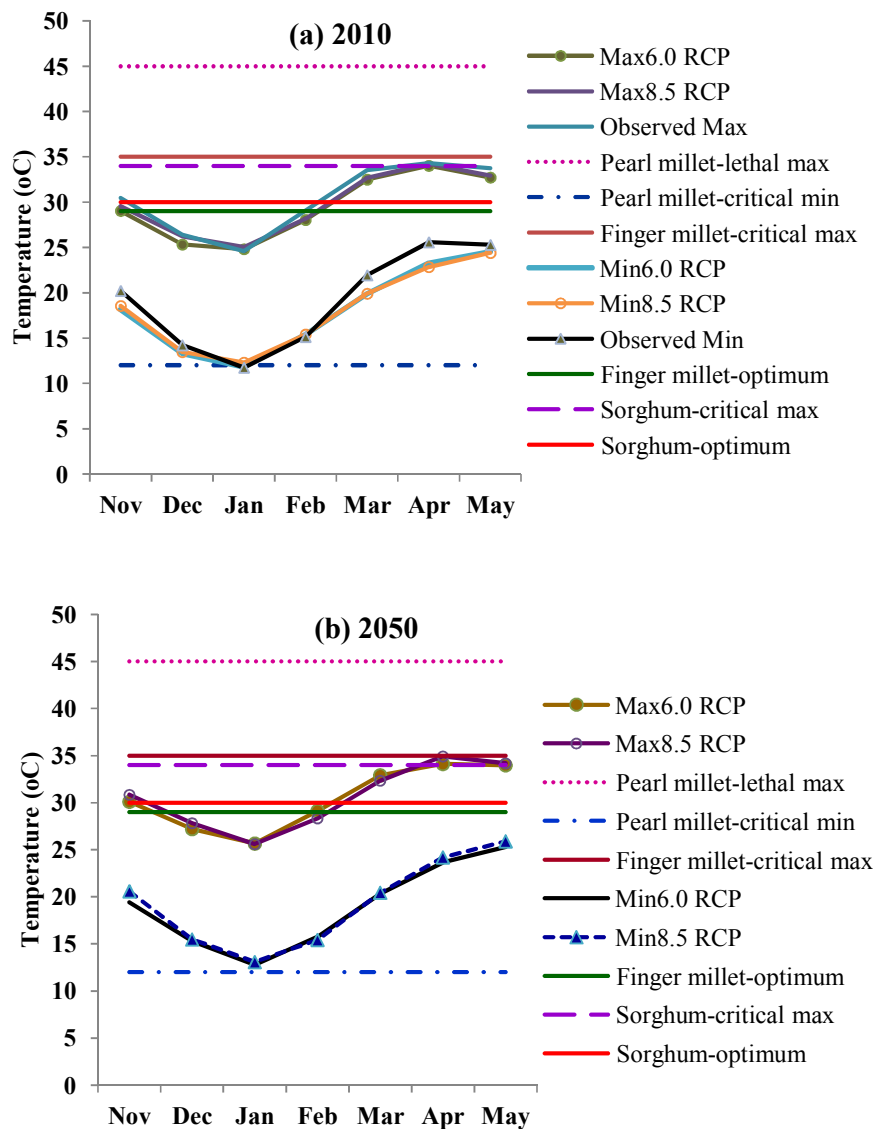


Fig. 5. Temperature domains for growing selected minor cereals in Bangladesh by (a) 2010 and (b) 2050 based on observed, RCP6.0 and RCP8.5 scenarios

soils are light-textured. Soil fertility is also low in those areas [22]. Bangladesh is a land of rivers of which four might rivers (Fig. 6) significantly transform land areas in their vicinity. Land reclamation and erosion are generally taking place in the vicinity of the Ganges, Jamuna, Meghna and Padma rivers [23,24]. The same is true with Brahmaputra river and a significant amount of land has already been reclaimed in the lower Meghna estuary and from the sea of the coastal area of the country [25]. However, the main constraints to use those lands are flood, erosion, land degradation and soil fertility depletion. On the other hand, hilly soils are mainly excessively to moderately well-drained, sandy loams to sandy clay loams, strongly to extremely acidic having low moisture holding capacity and low organic matter contents under shifting cultivation [25]. Farmers generally use such types of soils if there is no water stagnation.

On average, grain yields of minor cereals in Bangladesh are $1.2-2.0 \text{ t ha}^{-1}$, which is lower than the yield in China but similar to India [9]. It is agreeable that climate change can have an impact on yield of crops and thus it has to be addressed for attaining food security of many developing countries. The window of optimum temperature for growing sorghum and finger millet in Bangladesh will be reduced greatly by 2050 compared to 2010 (Fig. 5) because of temperature rise. Global mean surface temperatures will likely increase by $3.7-4.8^\circ\text{C}$ at the end of 21st century compared to 1850-1900 if no mitigation measure is adopted to reduce GHG emission [26]. Since minor cereals are rich in nutritive values [27] and can fix carbon even under high temperature and low nitrogen conditions [14,15], improved management and variety development would be essential for food security in the future.



Fig. 6. Major river systems of Bangladesh

Source: <http://www.mowr.gov.bd/index.htm>

Millets are hardy crops that generally mature in about 60-100 days having valuable marketing traits, especially they are rich in phosphorus, potassium, iron and magnesium and suitable for diabetic patients [9,16]. They require less added nutrients and can be grown without pest control measurements than other economically important crops [28]. The diversified uses of millets are still recognized by the farmers (Table 1) and encouraged to cultivate those crops. Besides, millets are drought tolerant and can be grown under a wide range of weather conditions [29] along with less GHG emission than other cereals, which could be beneficial in reducing the contributions from the agriculture sector. For example, carbon emission for millet cultivation was only 878 kg C ha⁻¹ compared to 1042 kg C ha⁻¹ for wheat cultivation [28]. Such scenario may indicate that cultivation of minor cereals is climate smart for reducing GHG emission. In future, the prevalence of insect pests and diseases and droughts are likely to be increased because of climate change impact. Besides, consumption of major cereals as staple food does not guarantee nutrient security of the people, especially in developing and under developed countries. So, growing minor cereals having high nutritive values and their uses with staple food could be an avenue of food security in many parts of the world.

5. CONCLUSION

Minor cereals are tangible food source in many parts of the world, having high nutritive values. In Bangladesh, minor cereals are mostly produced by the small farmers living in the harsh environment or unsuitability of lands for growing major cereal crops. Grain yield is comparatively low that need to be addressed to meet up future demands for nutritious foods under changing climate and decreasing suitable lands for agriculture. Among different minor cereals, *P. miliaceum* and *S. italic* are dominant in Bangladesh. The development of high-yielding varieties and appropriate agronomic management would be beneficial for sustaining food production in unfavorable ecosystems. As extreme events are increasing because of climate change impacts, drought and high temperature tolerant crops will be needed in future, although critical maximum temperature range might not be a problem for growing minor cereals in Bangladesh.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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