Climate change and rice production

by **Jayanta Kumar Basak**

Global and regional weather conditions are predicted to become more hazardous than those in the present time, taking into consideration increased frequency and severity of extreme events like cyclones, floods, hailstorms and droughts. Agriculture is always vulnerable to unfavourable weather events and climate conditions. Despite technological advancements for improved crop varieties and irrigation systems, weather and climate are important factors which play a significant role in ensuring agricultural productivity. The impacts of climate change on agricultural food production have become global concerns and for that matter Bangladesh, where lives and livelihoods depend mainly on agriculture, is exposed to a great danger as the country is one of the most vulnerable countries to climate change.

Bangladesh has a large agrarian base with 76 per cent of the total population living in the rural areas and 90 per cent of the rural population directly related with agriculture. Increasing food production and attaining food security in Bangladesh require sustainable growth in agricultural sector. The agro-economic contribution is 20.83 per cent of the Gross Domestic Product (Bangladesh Economic Review, 2009). The agricultural sector, comprising 48.1 per cent of the country's labour force, is already under pressure because of increase in the demand of foods and problems associated with the depletion of agricultural land and water resources. The issues of climate change make the pressure more acute.

Rice is the staple food for 150 million population of the country. The population growth rate is 2 million per year. At this growth rate, the total population will become 233.2 million by 2050. However, she faces a tremendous challenge while providing food security to the increasing population. Therefore, it is imperative to increase rice production in order to meet the increasing demand for food in accordance with population growth, although there have been ups and downs in the domestic production of food grain. The diverse climatic phenomena including cyclone, drought, changing rainfall patterns and temperature have resulted in a significant loss in food grain production. For example two rounds of floods and devastating cyclone Sidr in 2007 and cyclone Aila in 2009 caused severe damages to agricultural production, especially the rice production. Therefore, to meet the challenges faced by the agricultural sectors from the climatic conditions requires systematic integration of environmental and economic development measures for sustainable growth in agriculture.

A simulation study has been conducted by us to assess the vulnerability of boro rice production (58 per cent of the total rice production during 2008) in Bangladesh to see the effects of potential climate change. Effects of climate change on yield of boro rice have been assessed using DSSAT (Decision Support System for Agrotechnology Transfer, version 4) in six major rice growing regions (Rajshahi was selected from Rajshahi division; Mymensingh was selected from Dhaka division; Satkhira from Khulna division; Barisal from Barisal division; Comilla from Chittagong division; and Sylhet district from Sylhet division). Soil and hydrologic characteristics (percentage of clay, silt and stones, organic carbon, cation exchange capacity, pH in water, etc) of these locations, and typical crop management practices (Row spacing, Planting depth, Genetic coefficient, Transplant age, Plant per Hill, Application of irrigation 860mm in 14 applications, Fertilizer (Urea, N) application 125 kg/ha in 3 applications, etc), traditional growing period (Planting data 15 January) and weather data (daily average maximum and minimum temperature, daily precipitation, daily average solar radiation and carbon dioxide) in 2008 were used in the simulations. According to the Intergovernmental Panel on Climate Change, the global mean surface temperature is projected to rise by between 1.8°C (with a range from 1.1°C to 2.9°C for SRES B1) and 4.0°C (with a range from 2.4°C to 6.4°C for A1) by 2100. Another important climate change phenomena is the increase in the atmospheric carbon dioxide concentrations. Depending on the SRES emission scenarios, the atmospheric CO2 concentration is projected to increase from ˜379ppm to >550ppm by 2100 in SRES B1 to >800ppm in SRES A1FI. Here we have considered the increase of carbon dioxide at a level of 50ppm, 100ppm and 200ppm with 379ppm to see its individual and combined effects on boro rice yield.

DSSAT model predicted the maximum boro rice production for Comilla district (5427 kg/ha) and minimum was predicted for Rajshahi (3102 kg/ha) in 2008. It also found that the production in Barisal, Comilla and Sylhet districts were above 5000 kg/ha, whereas in Rajshahi and Satkhira it was below 4000 kg/ha. Boro rice production varies at different locations in Bangladesh for different climatic conditions and hydrological properties of soil (variety and management practices of Boro rice were the same for all simulations). Comparing the simulation results of rice production in terms of location, it is clear that Rajshahi is the most vulnerable rice growing region where climatic parameters play a dominant role with significant fluctuations of day and night temperatures in the winter season.

The growth and yield of crops are directly related to the rate of photosynthesis and phrenology and theirresponse to temperature. Optimum temperatures for maximum photosynthesis range between 25 and 30°C for rice under the climatic conditions of Bangladesh. Our findings from the model show that the effects of maximum temperature would drastically reduce rice yield at all selected locations. Boro rice yield would be reduced at a range between 2.6 percent and 13.5 per cent because of increase of 2°C maximum temperature and between 0.11 and 28.7 per cent for 4°C maximum temperature (base year 2008). The average value (average percentage change of rice yield for 6 locations) of boro rice yield reductions are 6.10 per cent and 16.0 per cent for 2°C and 4°C increased maximum temperature, respectively. Like maximum temperature, minimum temperature has also negative impacts on boro rice yield, which is estimated to be reduced by between 0.40 per cent and 13.1 per cent for the increase between 2°C and 0.11 and 15.5 per cent for 4°C minimum temperature. The average figures of yield reductions for minimum temperature are 4.2 per cent for 2°C and 8.5 per cent for 4°C. Therefore, increase in temperature has more negative impacts on rice yield compared to the minimum temperature. Combined effects of maximum and minimum temperatures are more significant compared to their individual effect on rice production in Bangladesh. Boro production is estimated to have a drastic reduction rate due to increasing maximum and minimum temperature of 2°C and 4°C and it may be from 3.2 to 18.7 per cent and from 5.3 to 36.0 per cent for rising temperature in case of both 2°C and 4°C, respectively. The average figures of yield reductions of the two temperature parameters are 10.4 per cent for 2°C and above 22.9 per cent for 4°C.

Atmospheric CO2 is vital for photosynthesis, and rise in CO2 concentration would increase the rate of plant growth. Photosynthesis is the net accumulation of carbohydrates formed by the uptake of CO2. So it increases with the increase in CO2 (Parry, 1990). Increase in the atmospheric CO2 concentration is likely to have some positive effect on rice yield, but the effect is not so significant compared to the negative effect of temperature. If the level of atmospheric CO2 concentration increased by 50ppm from the year of 2005 (IPCC reported value 379ppm), Boro rice yield would be estimated to increase by between 2.1 and 4.4 per cent and it would be between 4.0 and 9.6 per cent for 100ppm and between 5.2 and 18.2 per cent for 200ppm. The average values are 3.5 per cent, 6.5 per cent and 12 per cent for 50ppm, 100ppm and 200ppm CO2 concentrations respectively. Simulation studies were also conducted under different climatic scenarios of temperature and carbon dioxide concentration. Maximum scenarios show the negative effect on rice production in Bangladesh. Scenario like Tmax 2°C+ Tmin 2°C+200 ppm CO2 has some positive effect on rice production (1.37 per cent yield increase) but those positive effects cannot be considered when compared to the negative effect of other scenarios. The most significant negative scenario is Tmax 4°C+ Tmin 4°C+50ppm CO2 (24.7 per cent yield reduced).

Climate change threatens rice production with a significant challenge. The global warming and its consequent effect of climate change are attributed directly or indirectly to human activities that alter the composition of global atmosphere. Although contributing insignificantly to the causes of climate change, developing countries are expected to be the worst victims. Due to its geographic location, Bangladesh is one of the most disaster-prone countries in the world and due to the adverse impact of climate change natural calamities are predicted to be even more intense and frequent in the coming years. Besides, the countrywide environmental condition is not the same. There are some heavy rainfall regions, some drought- prone and others flood- and cyclone-affected regions in Bangladesh. These phenomena are closely related with climatic conditions of these regions. So, selection and development of temperature- and drought-tolerant rice varieties would be a major challenge for increasing rice production. Location-wise rice varieties selection depends on the environmental and hydrological criteria. Increasing productivity requires new knowledge both in maintaining yields and improving the quality of production. The needed knowledge is primarily biological in nature. It also includes the social science and technical knowledge. An important gap lies in the lack of weather stations in many districts, where climate change is expected to have important local impacts. These impacts cannot be assessed perfectly without reliable weather data. Increased investment in regular and timely collection of weather data in local areas should be given high priority for protecting rice production in those regions. There is a need for more reliance on scientific knowledge and assessment of viable options and bridging the gap among policy makers, research organisations, agricultural extension workers and farmers. Besides, farmer-centred investment is required for adapting to new climatic conditions. Above all, these should become major priorities while integrating climate adaptation into national policies, strategies and programmes and formulating budget for agriculture, forestry and fisheries.

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