JUST AGRICULTURE multidisciplinary e-Newsletter

Rice cultivation under changing climate with mitigation practices

Sonali Abrol[1], Devanshi Pandit[2*], Dechan Choskit[3] , Sheikh Saima Khushboo[4]
[2*]Shoolini University of Biotechnology and Management Sciences, Solan (H.P.)
[1,3,4]Division of Plant Pathology,
Sher-e- Kashmir University of Agricultural Science and Technology of Jammu
[*]*Corresponding author:* devanshipandit@shooliniuniversity.com

ARTICLE ID:026

Abstract

Assessments of the impact of climate change on rice production in Asia that comprehensively consider the uncertainty, would therefore be very valuable for predicting future food security in the region. With the increase in daily maximum temperature averaged over flowering period above about 36°C, rice yield generally declined because of spikelet sterility induced by high temperatures. Methane emission from the rice fields is estimated to be globally 37 Tg yr-1 by IPCC while N_2O emission is much lower as the total N_2O emission from overall cultivated area was put at 1.8–5.3 Tg yr-1. Reduction of stomatal conductance due to elevated CO_2 has been commonly observed in rice. However, the response of stomatal conductance to elevated CO_2 varies considerably in response to various environmental factors. The response of stomatal conductance to elevated CO_2 varied widely among times of day, growth stages, and years. Cultural and soil disturbances, pre-flooding and post-harvest drying contribute about 15% of the seasonal methane emission.

Introduction

Rice is one of the staple foods in South East Asia. More than 90% of the world's rice is produced in Asia. Rice accounts for about 60% of production in this region. Scientists predicted that under climate change scenarios, rice production in Asia will decline. Climate change will cause tremendous damage to rice production sector if not addressed properly. Assessments of the impact of climate change on rice production in Asia that comprehensively consider the uncertainty would therefore be very valuable for predicting future food security in this region. Rice cultivation has a wide geographic distribution in South East Asia, and climate change is likely to exacerbate a range of different abiotic stresses. This includes high

JUST AGRICULTURE
multidisciplinary e-Newsletter

temperature coinciding with critical developmental stages. This will also apply to floods causing complete or partial submergence, salinity which is often associated with sea water inundation/intrusion and drought spells that are highly deleterious in rainfed systems. Sometimes climate changes directly affect rice plant growth through changes in precipitation, evapotranspiration, air temperature, and water temperature. One of the major drivers of global warming is increased atmospheric CO_2 concentrations in the future, which may also enhance plant growth through the fertilization effect as because CO_2 is an essential component of photosynthesis.

Low supply of rice due to low production along with increasing demand not only affects economy of the country but also food security. The main important climate change factors are increase in temperature, increase in intensity, frequency, and duration of extreme climate events such as floods, droughts, and tropical storms; changes in the intensity, soil degradation; timing and spatial distribution of rainfall; and sea level rise resulting in flooding, loss of agricultural land and salt water intrusion.

1. **Temperature Changes under Rice Cultivation**:

Temperature increases are likely to cause increased evaporation from soil and therefore accelerated transpiration in the plants themselves. This might cause moisture stress. A higher air temperature will accelerate the natural decomposition of soil organic matter and increases the rates of other soil processes that affect fertility. Warming will accelerate many microbial processes in the soil-floodwater. Intensified evaporation will also increase the hazard of salt accumulation in the soil. With the increase in daily maximum temperature averaged over flowering period above about 36°C, rice yield generally declined because of spikelet sterility induced by high temperatures. Importantly, elevated CO_2 increased spikelet susceptibility to high-temperature damage. High night-time temperatures have been shown to have a greater negative effect on rice yields, with a 1°C increase above critical temperature (>24°C) leading to 10% reduction in both grain yield and biomass.

High day-time temperatures in some tropical and subtropical rice growing regions are already close to the optimum levels. High day-time temperatures in some tropical and subtropical rice growing regions are already close to the optimum levels.

JUST AGRICULTURE
multidisciplinary e-Newsletter

2. Atmospheric CO_2

Carbon losses due to growth and maintenance respiration typically amount to 40 to 60% of the total carbon fixed by a crop. Plant respiration as response to CO2 enrichment greatly varied among different studies. Plant respiration would decrease due to elevated CO2. Scientists had estimated that for every increase in 75 ppm CO2 concentration, rice yields will increase by 0.5 t/ha. So, increased concentrations of CO2 in the atmosphere has a positive effect on crop growth and yield with the condition that microsporogenesis, flowering, and grain-filling are not disrupted by increase in temperature. Elevated CO2 had a minor effect on rice nitrogen (N) uptake, which appeared to be associated with the relatively insensitive response of leaf area growth to CO2. Elevated CO2 accelerated rice development and increased leaf photosynthesis by 30-70%, canopy photosynthesis by 30-40% and crop biomass yield by 15-30%, depending on genotype and environment. However, the stimulatory effect of high CO2 concentration decrease gradually as the time of the exposure is prolonged.

3. Environmental Impact

Climate change will not only affect the water availability but also affect crop water use. Although a rise in temperature will increase evaporative demand, elevated CO_2 may reduce crop water use by reducing stomatal conductance. On the other hand, yield losses due to flooding may increase considerably sea level rise in the future as well as an increase in frequencies and intensities of flooding caused by extreme weather events. Rising sea level may amplify soil salinity, displace areas for crop production, and reduce rice production in a sizable portion of the highly productive rice land in deltas. Increasing threat of salinity is an important issue. Large areas of coastal wetlands may be affected by flooding and salinity in the next 50 to 100 years as a result of sea level rise the season Flooded rice fields emit significant amounts of methane (CH4) to the atmosphere.

More carbon dioxide in the atmosphere, coupled with rising temperatures, is making rice agriculture an even larger source of the potent GHG methane. Because global demand for rice will increase further with a growing world population, results suggest that without additional measures, the total methane emissions from rice.

JUST AGRICULTURE
multidisciplinary e-Newsletter

4. Drought and Rice Cultivation

Dry spells for a very short duration can result in substantial yield losses, especially if they occur around flowering stage. Drought affects all the stages of rice growth and development. Effects of drought on grain yield are largely because of reduction of spikelet fertility and panicle exertion. Frequent drought not only reduces water supply but also increases the amount of water needed for plant transpiration. Drought risk reduces productivity even during favourable years in drought-prone areas, because farmers avoid investing in inputs when they fear crop loss

5. Carbon Sequestration under Rice Cultivation

Rice cultivation is both an important sequester of carbon dioxide from the atmosphere and an important source of greenhouse gases (e.g. methane and nitrite oxide) emission. Methane production is negligible in upland rice because the fields are not flooded for any significant period of time. In rainfed lowland fields, methane emissions are much lower and more variable due to periods of no standing water during the season. Flooded rice fields emit significant amounts of methane (CH4) to the atmosphere. More carbon dioxide in the atmosphere, coupled with rising temperatures, is making rice agriculture an even larger source of the potent GHG methane. Burning of rice straw and direct incorporation of rice straw into the soil also produce GHGs. It should be noted, however, that relatively simple changes in rice cultivation could help reduce methane emissions. Methane is a major end product of anaerobic fermentation. It is released from submerged soils to the atmosphere by diffusion and release of gas bubbles and through roots and stems of rice. When the fields remain flooded for the entire growing season, there is more potential for CH4 emissions than when the fields are drained or permitted to dry at least once during the season. When CH4 is released into the atmosphere, it traps significant amounts of heat that would otherwise escape to space. Methane is more than 20 times more heat absorptive than CO2 and it has a 9 to 15 year life time in the atmosphere.

6. Pest and Disease Management

Rice crop suffers maximum due to infestation of a wide range of insect and non-insect pests under different ecological conditions. Rice crop is attacked by more than 100 species of

JUST AGRICULTURE
multidisciplinary e-Newsletter

insects; 21 of them can cause economic damage. On an average, the yield losses in the country due to insect pests are around 28%. Among the insect pests of rice, rice stem borer, leaf folder, case worm, whorl maggot, gall midge, rice hispa, gundhi bug, ear cutting caterpillar, thrips and grasshopper are some most important insect pests of rice. Frequent monitoring of pest population is necessary.

Some of the management of rice pests includes collection and destruction of egg, larvae, pupae and adults of different insects; putting of branches of neem, banmara, Eupatorium odoratum for repelling of insects and to facilitate the predatory bird to sit on; pulling of jute rope (dipping in kerosene mixed water) by two person through the rice field and immediately drain off the excess water if infestation of case worm occurs; stubble destruction soon after the harvesting for preventing the carryover of stem borer and gall midge; spraying of Nimbicidine @ 3 ml/L at 10 DAT followed by second spraying after 20 days interval; installation of pheromone trap for yellow stem borer @ 16-20 nos. per hectare in a triangular pattern at 60 m distance; release of *Trichogramma japonicum* or *T. chilonis* @ 50,000 per hectare at weekly interval for 7-8 times starting from 30 days after transplanting.

Diseases are considered as a major threat in rice cultivation and causes yield losses to the growers and also reduce the quality of the produce. There are a number of fungus, bacteria and virus, mycoplasma-like organisms cause disease in rice. Among the various diseases, blast, bacterial leaf blight, sheath blight, false smut, brown spot, stem rot, foot rot and Rice Tungro Virus (RTV)are very important diseases. Organic disease management in general, emphasizes prevention through the use of resistant varieties, good cultural practices, physical control methods, use of antagonistic microbes, quarantine, knowledge of the pathogen and disease biology, and disease-free certified seed. Chemical fungicides are not completely banned; some chemical fungicides are having restricted use in organic agriculture with the approval of certifying agency. Some of the major important disease in rice are Blast: *Pyricularia grisea*; Brown spot: *Helminthosporium oryzae*; Sheath blight: *Rhizoctonia solani*; Sheath rot: Sarocladium oryzae; Stem rot: *Sclerotium oryzae*. False smut: Ustilaginoidea virens; Bacterial leaf blight: *Xanthomonas oryzae pv. Oryzae*; Leaf streak: *Xanthomonas oryzae pv. oryzicola*; Tungro virus (Rice Tungro Virus). crops, aeration of water and alternating rice crops with other crops in the dry season are suggested methods of reducing methane emission. They have also suggested dry seeding in place of transplanting, for CH4 mitigation. Dry seeding is getting increasingly popular among farmers due to labour savings although it has a lower yield potential than transplanting. But this practice has to be tested for its effects on N_2O emissions.

Conclusion

The impact of cultivation practices like land preparation, seeding and transplanting, and other operations on methane emission from rice soils are now only beginning to be understood. Dry land tillage and direct seeding is expected to reduce methane emission as they have shorter anaerobic phase during rice culture. Minimization of soil disturbances during rice cultivation by adopting direct seeding and dry land tillage can reduce methane emission from rice fields. Cropping diversification and crop intensification wherein rice is grown in rotation with other crops like wheat, mustard, cowpea and maize will have distinct cycles of anaerobic and aerobic phases. This cycle of land conditions will reduce methane emissions than that from mono-culture of irrigated rice. A reduction in the application of N fertilizers and organic fertilizers would possibly reduce methane and N_2O emissions from rice fields, but would also reduce total rice production unless the area under rice cultivation is increased. Reducing the period of inundation, growing alternative crops, aeration of water and alternating rice crops with other crops in the dry season are suggested methods of reducing methane emission. They have also suggested dry seeding in place of transplanting, for CH4 mitigation.

References:

Amaratunga and Abeywardena, R.M.I. (2006). Physiology of yield determination of rice under elevated carbon dioxide at high temperatures in sub-humid tropical climate. *Field Crops Research.* 96: 336-347.

Barman, H., Roy, A. and S.K. Das. (2015). Evaluation of plant products and antagonistic microbes against grey blight (Pestalotiopsis theae), a devastating pathogen of tea. *African Journal of Microbiology Research.* 9(18): 1263-1267.

Das, S. K. and Mukherjee, I. (2012). Flubendiamide transport through packed soil columns. Bulletin of *Environmental Contamination Toxicology* 88: 229–233.

Das, S. K. and Mukherjee, I. (2014). Influence of microbial community on degradation of flubendiamide in two Indian soils. *Environmental Monitoring & Assessment*. 186: 3213–3219.

Das, S.K. (2013). Mode of action of pesticides and the novel trends-a critical review. *International Research Journal of Agricultural Science and Soil Science*. 3(11): 393-403.

Das, S.K. (2014) Recent development and future of botanical pesticides in India. *Popular Kheti* 2 (2): 93-99.

Das, S.K. (2014). Scope and Relevance of using Pesticide Mixtures in Crop Protection: A Critical Review. *International Journal of Environmental Science and Toxicology*. 2(5): 119-123.

Das, S.K. and Avasthe, R.K. (2015). Carbon farming and credit for mitigating greenhouse gases. *Current Science* 109(7): 1223.

Das, S.K., Mukherjee, I. and Kumar, A. (2015). Effect of soil type and organic manure on adsorption–desorption of flubendiamide. *Environmental monitoring and assessment*.187(7): 403.

Mate, C.J., Mukherjee, I. and Das, S.K. (2014). Mobility of spiromesifen in packed soil columns under laboratory conditions. *Environmental monitoring and assessment* 186 (11): 7195-7202.

Nguyen, V.N. (2002). Productive and environmentally friendly rice integrated crop management systems. *IRC News*, 51: 25–32.

Shimono, H., Masumi, O., Meguru, I., Hirofumi, N., Kazuhiko, K. and Toshihiro, H. (2010). Diurnal and seasonal variations in stomatal conductance of rice at elevated atmospheric CO2 under fully open-air conditions. *Plant, Cell and Environment*. 33: 322–331.

Watanabe, T. and Takashi, K. (2009). A general adaptation strategy for climate change impacts on paddy cultivation: special reference to the Japanese context. Paddy Water Environment. 7: 313–320.