Frank Notes

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Climate Change and Indian Agriculture

Greenhouse effect is a natural process that has kept the Earth planet warm at 14 ºC. In absence of greenhouse effect, average temperature of Earth would have been -19 ºC (33 ºC less). Greenhouse effect is useful having sustained life on Earth in its present form. Group of radiatively-active atmospheric gases such as carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), ozone (O_3), and water vapours have contributed to this life-sustaining phenomenon. Characterized by symmetric molecules, these gases are transparent to short-wave radiations coming from sun but can absorb earth's long-wave radiation being emitted into the space. Collectively termed as the greenhouse gases (GHGs), these act like a blanket insulating the Earth.

Start of industrial revolution in 1750 and intensification of modern agriculture at the beginning of 20th century witnessed a series of anthropogenic activities namely, industrialization, urbanization, land use changes, deforestation, etc. The multifaceted interactions among the humans, microbes and the rest of biosphere triggered a rise in the concentrations of greenhouse gases in the atmosphere. As per World Meteorological Organization report (2016), atmospheric concentrations of CO_2, CH_4 and N_2O increased from 278 ppmv, 722 ppbv and 270 ppbv in 1750 to 400 ppmv, 1845 ppbv and 328 ppbv, in 2015, respectively. Consequentially, average temperature of Earth has arisen by about 0.6 °C since 1950, increasing @ 0.17 °C per decade. Over past 100 years (1901 to 2007), India recorded a warming of 0.51 °C, with accelerated warming of 0.21 °C per decade from 1970 onwards. Climate change or global warming is already affecting the Earth's temperature, precipitation, and hydrological cycles. Rise in temperature *per se* and more frequent occurrence of droughts and floods etc. are the manifestations of climate change.

Carbon dioxide, methane and nitrous oxide are three important greenhouse gases arising out of agricultural intensification. Agricultural soils influence the climate change or global warming primarily through the emission and consumption of GHGs. In terms of global warming potential computed for 100 years, N_2O and CH_4 are 298 and 25 times more lethal than CO_2. Increase in the concentration of atmospheric GHGs is already causing warming across the globe. Besides rising temperatures directly impacting the crop yields, global warming will also cause steady rise in sea levels, increased cyclonic activity, and changes in precipitation patterns. Need of the hour is to put in place the appropriate mitigation and adaptation strategies to guard agriculture against the adverse effects of climate change and make it more climate-resilient.

Indian agriculture accounts for 7% of the GHG emissions from global agriculture. Its share to total GHG emissions of the country is 21%. As per latest estimates, emissions of CH_4 from rice paddies and N_2O from agricultural soils in India are 3.37 and 0.30 Mt/annum, respectively. Field burning of agricultural residues also contributes to CH_4 and N_2O emissions, but magnitude is small. Relative contribution of agricultural intensification on CO_2 emissions has been almost negligible compared to other sectors like burning of fossil fuels. Overall, the GHG emissions from Indian agriculture registered an increase of about 75% during 1970-2010.

Inter-government Panel on Climate Change has predicted that if no additional efforts to reduce GHG emissions are made and these emissions growth synchronizes with growth in global population and economic activities, global mean surface temperature will rise by 3.7 °C to 4.8 °C in 2100 compared to pre-industrial levels. Temperature change in India is likely to rise by 3 ºC to 4 ºC in 2100. These predictions combined with regression estimates indicate that in absence of any adaptation measures by farmers and any changes in policy (such as irrigation), farm income will witness a decrease of about 12% in coming years. Rainfed areas will be the most severely affected with potential losses amounting to 18% of the annual revenue. Cereal productivity is projected to decrease by 10-40% by 2100 due to increased temperature, increasing water stress and reduction in number of rainy days; greater loss is expected in *rabi* crops. For every 1 °C rise in temperature, yields of wheat, soybean, mustard, groundnut and potato are expected to decline by 3-7%. Rice yields may decline by 6% for every 1 °C increase in temperature. Water requirement of crops is also likely to go up with projected warming. Although in some regions, temperature and precipitation changes will have limited production benefits, in general a changing climate will result in overall lower agriculture yields.

Recognizing the likely impact of climate change as a major threat to sustainability of Indian agriculture, ICAR initiated a network project National Innovations on Climate Resilient Agriculture in 2010-11 to enhance the resilience of Indian agriculture to climate change and climate vulnerability through strategic research and technology demonstration on adaptation and mitigation strategies for crops, livestock, fisheries and natural resource management. Appropriate adaptation and mitigation strategies are being devised under National Action Plan on Climate Change.

Mitigation of methane emission from rice cultivation can be done through alteration in water management, particularly promoting mid-season aeration by short-term drainage; and improving organic matter management by promoting aerobic degradation through composting or incorporating it into soil during off-season drained period. Shifting to aerobic rice cultivation and adoption of system of rice intensification in place of flooded rice is a sustainable solution. Application of fermented manures like biogas slurry in place of unfermented farmyard manure also reduces methane emission.

The most efficient management practice to reduce nitrous oxide emission is site-specific nutrient management. Real-time N management using simple gadgets like leaf colour chart, SPAD meter etc., in rice and wheat shows the use of this technology in maximizing nitrogen use efficiency, minimizing N losses including minimizing N_2O emissions without any yield loss. Use of nitrogen extenders and additives like urease inhibitors - N-(n-butyl) thiophosphoric acid triamide, nitrification inhibitors such as nitrapyrin and dicyan-diamide and slow release N-compounds like gypsum/sulphur coated urea etc., increases the N use efficiency by up to 15% and reduce the N_2O emissions. The 4R-based site-specific N fertilization and topdressing of N fertilizer before irrigation of field etc., are other useful options.

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Evaluation of some plant-derived organics such as *neem* oil, *neem* cake and *karanja* seed extract as nitrification inhibitors in the country gave rise to development of neem oil coated urea. It led the country to go in for the 100% coating of urea with *neem* oil. It is a step in right direction. However, the prevailing fertilizer pricing policy under which the retail price of urea is very low *vis-à-vis* prices of phosphatic and potassic fertilizers, is leading to higher and inefficient use of urea. Sub-optimal use P and K nutrients drastically reduce the N use efficiency. This is harming the farmers, deteriorating the soil health, and subjecting the environment to rising N_2O emissions. Correction in fertilizer pricing policy is essential to promote the balanced and efficient use of nutrients.

Mitigation of CO_2 emission from agriculture can be achieved by increasing carbon sequestration in soil through manipulation of soil moisture and temperature, setting aside surplus agricultural land, and restoration of soil carbon on degraded lands. Soil management practices such as reduced tillage, manuring, residue incorporation and mulching can play an important role in sequestering carbon in soil.

To cope up with the impact of climate change, developing crop varieties tolerant to different stresses like drought, salinity and waterlogging is a first step. Practicing conservation agriculture with climate resilient crop cultivars relying on resource conservation techno-logies; efficient water and nutrient management; and integrated pest management practices is a win-win solution as it strives to sustain high production levels while concurrently conserving the environment. Further diversi-fication to integrated farming systems makes farmers more climate smart. Since the adaptation capacity of poor farmers is limited because of subsistence agriculture, there is need to evolve climate smart strategies which are simple to adopt, economically viable and culturally acceptable.

In conclusion, there is need to change the entire paradigm of Indian agriculture in the interest of soil health, farmers' income and environment. We have designed and implemented strategies for conservation agriculture and also adaptation of agriculture to climate change. Fertilizer policies need immediate correction in the interest of sustainable agriculture and secured future of our coming generations. ■