International Journal of Science, Environment and Technology, Vol. 5, No 2, 2016, 374 – 379
ISSN 2278-3687 (O)
2277-663X (P)

Review Article

YIELD POTENTIAL OF CROPS IN RELATION TO 'CHANGED CLIMATE' SCENARIO[1]

Ambika Prasad Upadhyay
Principal Scientist,
ITC Life Sciences & Technology Centre, Peenya, Bangalore 560 058
Email: shriambika369@gmail.com

Abstract: Recently released Fifth Assessment Report by IPCC presents yet another set of strong & conclusive evidence for a changed climate due to anthropogenic factors. The report also presents, with various degrees of certainty (or uncertainty), wider impact of climate change at global and regional levels on agriculture. Because of its inherent climate sensitive nature the impact of changed climate is direct &most obvious on agro-ecosystems and, due to its disruptive influence on agricultural production systems, it is a major cause of social vulnerability. The impact of climate change is going to be particularly exacerbated in future under Indian conditions where natural climatic variability, especially for summer monsoon, is going to be significantly higher with much more frequent occurrence of extreme wet and dry conditions. Undoubtedly, sustaining agricultural production under changed climatic scenario is going to be daunting task, particularly under rainfed conditions where crop production already suffers from multiple biotic &abiotic stresses. The other important negative effect of climate change due to worsening weather conditions is deteriorating nutritional and market value of produce. The only realistic option to alleviate the impact of climate change and sustain agricultural production is to develop adaptation strategies at local level after assessing the nature and extent of vulnerability of different agricultural production systems. Adaptation strategies have to be based on sound understanding of eco-physiological mechanisms involved in yield losses due to various biotic/abiotic stresses emanating from climate change related weather conditions and developing agro-techniques that not only minimize climatic risk but also reduce agricultural carbon foot print and therefore, its contribution to global warming. If we were to be successful in facing the challenge of increased agricultural productivity in changed climate scenario, a major paradigm shift in agricultural research mindset is needed from a mere 'cost-benefit ratio approach' to a sustainable 'carbon-benefit approach'.
Keywords: Climate change, yield potential, rainfed system.

Introduction

The term Climate Change has a misleading connotation and, perhaps, a popular perception that it is a change that is likely to happen in future. In reality, however, there is mounting evidence for a significant and measurable change clearly evident through a much higher levels of CO_2 and a warmer planet ((IPCC, 2014). With limited mitigation measures in place to curb the emissions, in future this change is most likely to continue unabated and getting

*Received Feb 8, 2016 * Published April 2, 2016 * www.ijset.net*

further exacerbated by anthropological activities. Although there are many direct and indirect manifestations of the changing climate e.g. higher temperatures, rise in sea levels but the one which is most damaging and also most difficult to cope with is the frequent occurrence of extreme weather conditions. In India where agricultural production is tightly linked with monsoon, there is already concluding evidence for significant increase in the occurrence of extreme wet/dry conditions with significantly higher frequency of occurrence (Singh *et* al., 2014) with real possibility of frequent crop failures. Undoubtedly, climate change has emerged as major threat to agricultural production just when there is urgent need to enhance agricultural productivity to meet ever increasing demand for quality food. The challenge is particularly daunting for Indian agriculture where we need to produce more with lesser resources and without further damaging the natural resource base (Lal, 2004). With limited scope for further extensification (bringing more land under cultivation), sustainable intensification is the only real option available to enhance agriculture productivity however, success in sustaining the agricultural production in future will depend on our capacity to adapt and develop region specific production strategies to counter the impact of climate change. Here, three important aspects to adaptations are briefly discussed – understanding the eco-physiological mechanisms for yield reduction, development of green& carbon positive agro-technologies for mitigation & adaptation and lastly, capacity building for adaptation to alleviate impacts of climate change on agriculture.

In order to adapt successfully, it is vital to have a robust understanding of the causes of yield reduction in different crops and their sensitivity to various climatic factors. Literature is replete with reports of impact of climate change on crop yields and most studies suggest a certain decline in yields for most crops, particularly in tropics, where crop growing conditions are already harsh in terms of supra-optimal temperature and sub-optimal water availability. However, there is high degree of uncertainty in such assessments of impact of climate change on crop productivity mainly due to limited understanding of multi factor crop-climate cause-effect relations at micro level (Rotter, 2014). Therefore, it is important to develop a sound basis for crop-climate interactions based seasonal yield variations for different crops as each crop has different levels of sensitivity to climatic factors & region specific vulnerability. Yield potential has been defined as “the yield of a cultivar when grown in environments to which it is adapted; with nutrients and water non-limiting; and with pests, diseases, weeds, lodging, and other stresses effectively controlled” (Evans, 1993). From this definition it is obvious then the resultant yield potential in a given environment is net integrated result of frequency and severity of multiple biotic & abiotic stresses operating at different stages of crop growth. Crop response to a particular stress in isolation is different than the combined impact of multiple stresses because there are interactions between different stresses (Mittler, 2006). For example, in soybean, high temperatures for a delayed planting crop will have much more negative impact than normal planted crop whereas in rice such an additive impact will be much lesser in magnitude. Therefore, to have realistic estimates of impact of climate change on crop productivity in a given region there is need to investigate the impact of multiple stresses along with frequency and severity in agro-meteorological research. Such responses can be successfully integrated through modeling approaches for developing right strategies of crop management and decision making.

Besides agriculture getting impacted by climate change, it is also well established that agriculture sector is also one of the major contributor to greenhouse gas (GHG) emissions – together with forestry, farming is the largest contributor to man-made emissions (Natasha, 2011). In this context it is important to reduce the carbon foot print of agricultural production to make it environmentally benign with an ultimate objective to target for a net 'carbon positive agriculture' where total GHG mitigation exceeds the total emissions. In fact, it has been estimated that Indian agriculture has huge mitigation potential through reducing emissions and enhancing sinks (Smith, 2012). Increasing agricultural production and mitigating climate change may seem contradictory objectives but there are opportunities to accomplish the twin objectives. For example, recent work in National Initiative on Climate Resilient Agriculture (NICRA) have successfully demonstrated that it is possible to achieve yield gains with reduced emissions by adopting new and innovative technologies (Maheswari, 2014). In rice cultivation also, which is major contributor to GHG emissions from agriculture sector it is possible to achieve yield gains with reduced GHG emissions with the adoption of new technologies (Jain *et al.,* 2014). Agro-forestry, as a land use system has huge potential for carbon sequestration and therefore, it is a most viable option to mitigate climate change (Jose, 2009). In India this traditional land use system has the potential to sequester 25 to 40 Mg C ha^{-1} yr^{-1} and can also ensure food, fodder and wood security (Sudha *et. al.,* 2007; Prasad *et. al.,* 2012; Ajit *et. al.,* 2013). An agroforestry system with pulp wood plantations is already being successfully adopted by large number of farmers in Andhra Pradesh and other states where it has not only enhanced farm income and ensured raw material supply to paper industry but it has contributed to sustainability of the systems through its mitigating potential.

Given the fact that now climate change is reality that we have to live with and manage the agricultural production, most important is level of preparedness to face this challenge. Madhya Pradesh is one of the mostvulnerable state to climate change (MP-SAPCC, 2012) because of its agro-climatic conditions and limited adaptation capacity. Madhya Pradesh Sate Action Plan on Climate Change (MP-SAPCC) has suggested some adaptation measures which are mainly foucussed on soil & water conservation and fertilizer and irrigation management. These are important steps to insulate the state agriculture from high risk of crop failures. However, one important part of this prepared ness has to be human resource capacity building at every level. This requires stregnthening of climate change research at state level and training of extenssion workers and farmers. It is important to realize that there can not be climate smart or climate resilient agriculture without climate smart farmers. In subsistence farming farmers adopted traditional ways of coping with climatic variability essentially by spreading risk and which was based on ‘low gain – low risk’ strategies. However, this strategy is not very effective in modern, ‘high input-high output’ agriculture. Therefore, the importance of institutional and social capacity building can not be over emphasized.

There is enough evidence to suggest that with right technologies it is not only possible to enhance the crop yields but also reduce emissions. Therefore, the objective should be to develop ‘carbon positive’ agro-techniques as good agricultural practices (GAP) and a sustainability audit of existing and new package of practices should become mandatory to assess the yield gains for per unit of emissions. Climate change has profound implications to agriculture and requires radically new and innovative approaches to farming which are ecologically benign, resource use efficient and socially inclusive. Lastly, an important part of preparedness for the potent threat of climate change also calls for an immediate need for education and training on climate change related issues to all the key stake holders in order to have a new generation of climate smart researchers, extension workers and farmers.

To conclude, Indian agriculture is faced with unprecedented twin challenge of producing more food to meet ever increasing demand for burgeoning population and adaptation to climate change. It requres an innovative anapproaches to farming (e.g. Fedoroff *et al.,* 2010) and major paradigm shift in agricultural research.As Ruttan (1999) aptly emphasized the role of innovation “*If the world fails to successfully navigate a transition to sustainable growth in agricultural production, the failure will be due more to a failure in the area of institutional innovation than to resource and environmental constraints.”*

REFERENCES

[1] Ajit; Dhyani, S.K.; Ramnewaj; Handa, A.K.; Rajendra Prasad; Alam, Badre, Rizvi, R.H.; Gupta, G.; Pandey, K.K. Jain, A. and Uma. 2013. Modeling analysis of potential sequestration under existing agroforestry systems in three districts of Indo-gangatic plains in India. *Agroforest Syst*. DOI 10.1007/s10457-013-9625x.

[2] Evans, L.T. 1993. Crop evolution, adaptation and yield. Cambridge Univ. Press, Cambridge.

[3] Fedoroff, N.V.; Battisti, D.S.; Beachy, R.N; Cooper, P.J.M; Fischhoff, D.A; Hodges, C.N.; Knauf, V.C.; Lobell, D.; Mazur, B.J.; Molden, D.; Reynolds, M.P.; Ronald, P.C.; Rosegrant, M.W.; Sanchez, P.A.; Vnshak, A. and Zhu, J.K. 2010. Radically rethinking agriculture for the 21st century. *Science* 327: 833-834.

[4] GoMP Climate Change Cell. 2012. Draft Madhya Pradesh State Action Plan on Climate Change. http://moef.nic.in/downloads/public-information/MP-SAPCC.pdf

[5] IPCC, 2014. Summary for policy makers. In: *Climate Change 2014: Impacts, Adaptation and Vulnerability.* WG II Fifth Assessment Report. Field et. al., (eds). Cambridge Univ. Press, Cambridge.

[6] Jain, Niveta; Dubey, Rachna; Dubey, D.S.; Singh, Jagpal; Khanna, M.; Pathak, H. and Bhatia, Arti. 2014. Mitigation of greenhouse gas emission with system of rice intensification in the Indo-Gangetic Plains. *Paddy Water Environ.* (Online advance publication).

[7] Jose, S. 2009. Agroforestry for ecosystem service and environmental benefits: an overview. *Agroforest. Syst.*76: 1-10.

[8] Lal, R. 2004. Soil carbon sequestration in India. *Climate Change*. 65: 277-296.

[9] Maheswari, M; Srinivasa Rao, M.; Rao, V.U.M.; Srinivasa Rao, CH.; Reddy, K.S.; Ramana, D.B.V.; Rama Rao, C.A.; Vijay Kumar, P.; Prasad, Y.G.; Venkateswarlu, B. and Sikka, A.K. 2014. National Initiative on Climate Resilient Agriculture (NICRA), Research Highlights (2013-14). Central Research Institute for Dryland Agriculture, Hyderabad. 116 p.

[10] Natasha, G. 2011. Summit urged to clean-up farming. *Nature,* 479: 279.

[11] Mittler, Ron 2006. Abiotic stress, the field environment and stress combination. *TRENDS in Plant Science,* 11 (1): 15-19.

[12] Prasad, J.V.N.S.; Srinivas, K.; Srinivasa Rao, CH; Ramesh, CH; Venkatramma, K. and Venkateswarlu, B. 2012. Biomass productivity and carbon stocks of farm forestry and agroforestry systems of leucaena and eucalyptus in Andhra Pradesh, India. *Current Science*.103(5): 536-540.

[13] Rotter, R.P. 2014. Robust uncertainty. *Nature Climate Change,* 4:251-252.

[14] Ruttan, V.W. 1999. The transition to agricultural sustainability. *Proc. Natl. Acad. Sci*. 96: 5960-5967.

[15] Singh, Deepti; Michael Tsiang; Rajaratnam, Bala and Diffenbaugh, Noah S. 2014. Observed changes in extreme wet and dry spells during the South Asian summer monsoon season. *Nature Climate Change* (www.nature.com/natureclimatechange).

[16] Smith, P. 2012. Agricultural greenhouse gas mitigation potential globally, in Europe and in the UK: what have we learnt in the last 20 years ? *Global Change Biology*. 18: 35-43.

[17] Sudha, P.; Ramprasad, V.; Nagendra, M.D.V.; Kulkarni, H.D. and Ravindranath, N.H. 2007. Development of an agroforestry carbon sequestration project in Khammam district, India. *Mitig. Adapt Strat Glob Change.* DOI 10.1007/s11027-006-9067-0