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Climate Resilience in Agriculture in Context to Changing Climatic Scenario

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INTRODUCTION

A significant and long lasting change over long periods of time in statistical properties of the climate is termed as climate change. These changes in climatic conditions have decreased crop yield due to insufficient rainfall, several abiotic/biotics stresses and prospective weeds etc. Earth's natural factors such as solar radiation, continental glide along with environmental pollution, natural imbalance because of human activities are some of the major reasons causing climate change. Such changes in climate directly effects agricultural sector and on the contrary increasing agricultural practices caused environmental pollution, emission of greenhouse gases at a larger scale ultimately leading to climatic changes (Adams, 1989). Agriculture which is a major industrial segment adds around 14% global greenhouse gases directly and 17% of additional emissions indirectly. Consequently, agricultural production serves both ways- a major contributor as well as potential mitigating and adaptive force towards changing climate.

The development of new innovations in agriculture sector has become the need of hour due to several emerging issues in changed climate. The worldwide increasing demand of food can be meet out either by increasing the area under production or by improving productivity on available arable land. Invention and development of new technologies is also needed to meet out the target of increasing outputs in comparison to inputs to finally enhance the agricultural production.

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Various advanced agricultural practices along with new developments in the area of biotechnology can serve a vital role in mitigating climate change. Germplasm collection and utilization of naturally existing wild relatives to isolate tolerant/resistant genes, alleles or QTLS for various biotic/abiotic stresses can be a very effective strategy. Advanced genomic strategies like molecular breeding, genetic engineering and integrated breeding can prove to be very effective for development of modified crops which can better adapt under various stresses.

Industrial agriculture and climatic variations

Environmental Protection Agency (EPA) observed that rise in greenhouse gases in the atmosphere is the major cause of changes in the climate. Carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) and ozone (O_3) are among some of the foremost greenhouse gases in the atmosphere while halocarbons are man-made. The increased levels of these gases cause greenhouse effect by increasing the infrared opacity of the atmosphere leading to rise in the temperature of the earth's atmosphere. This may further result into rise of around 2-3°C in global temperature up to 2050 subsequently increase in sea levels and changes in vegetation prototype and migration of animals.

Agriculture sector which is one of the largest industries contribute to the greenhouse gas emissions due to use of industry based inputs such as machinery and fertilizers ultimately leading to climatic changes. Thus, it is necessary to know the use of present industrial system like equipments and methods used post-green revolution in agriculture sector to know about its effect on climate change (Calzadilla et al., 2010). Green revolution was a big upheaval for world's food system and it replaced the major ecological system with technological developments leading to significant improvements in agriculture. But, later on this system soon started shifting towards mechanized farming instead of ecological methods causing climate changes.

Technological advancement had a very large impact on agriculture and thus it was very difficult to restrict all the factors of agriculture associated with greenhouse gas emission due to several political and social factors. Nowadays, alternative arrangements such as Polyface and different sustainable farms are required for growth and support of current agricultural system but on the other hand the increased emission of greenhouse gases should also be kept in mind to fight climate change. Therefore, the emerging biotechnological and molecular breeding approaches can prove helpful for improving current agricultural system along with minimizing the direct effect of agriculture on changing climate and subsequently the issue of emissions of greenhouse gases may be resolved (Di Falco et al., 2013).

Strategies for adaptation and mitigating climate change

Several conventional and advanced strategies including biotechnological, breeding and agronomic approaches may be used to address the issues of climate change adaptation and mitigation. Agricultural biotechnology can be used effectively to tackle the issues related to changing climate by using mitigation strategies, generating adaptation techniques and reduce the use of agricultural practices causing changes in climate. Climate change mitigation strategies generally focus on reduction of the resources or diminish the impact of negative effects of changing climate caused due to human interventions. It mainly helps to reduce the concentration of greenhouses gases by decreasing their sources or by raising their sinks. In addition, climate change adaptation strategy also deals with decreasing the susceptibility of natural and human systems towards effects of changing climate. Moreover, biotechnology also helps to reduce on farm fuel utilization by minimizing use of chemical inputs or using low till or no till methods of agriculture.

Biotechnology also provides genetically modified organisms (GMOs) approach to lower down the needs of fertilizers in comparison to conventional farming.

Arcadia Biosciences developed rice and canola varieties using genetically modified (GM) approach which can use nitrogen more efficiently thus reducing the use of fertilizers. Thus, such technique termed as nitrogen use efficiency (NUE) helps farmers to get equivalent yields without using nitrogen fertilizers, lowers greenhouse gases emission by reduced fertilizer application and reduction in pollution of ground or surface water caused because of nitrogen usage. Thus, GMOs and other associated technologies such as organic farming can minimize use of farm fuel, fertilizers, pesticides and herbicides resulting into reduction in CO_2 emissions. Eco-friendly fertilizers (composted humus and animal manure) based on microbial techniques must be used to minimize the negative effects of artificial fertilizers. In addition, different good agronomic practices such as land management, crop rotation, mixed farming, intercropping through leguminous plants having nitrogen fixing capability and use of traditional and indigenous methods of controlling pests and disease methods can be also very fruitful.

In addition, various adaptation strategies besides mitigation strategies are also very important to minimize the effects of climate. Biotechnology as well as application of other advanced practices like molecular breeding in agriculture may help in developing plants which can adapt under new climatic conditions and can be utilized to achieve higher yields as well as food security for growing population with inadequate water and land resources.

Adaptation for abiotic stresses

Different abiotic stresses like drought, salinity, extreme temperatures, oxidative stress and chemical toxicity enforce negative impact on environment and agriculture and due to climatic changes such effects show more effect. Rise in sea level has increased water salinity resulting into forced migration and larger population density which will ultimately reduce viable land for agriculture and fresh water for irrigation. It has been predicted that it if increase in salinity continues at the same rate it may cause 30% loss of arable land upto 2025 and 50% by 2050 (Mendelsohn et al., 2009). On the other hand, with increasing harsh conditions, plants utilize more energy thus taking more water to grow. Agriculture sector approximately uses 70% of available fresh water which can certainly increase along with increasing temperature due to climate change. Thus, such strategies are needed to develop for agriculture sector for adaptation of crops to various abiotic stresses like drought, salinity etc. which can help to conserve water and land as well as can give higher yield to meet the food demands of growing population (Bates et al., 2008). Due to increasing population worldwide and reduction in fertile land due to climate change it becomes important to generate more space-efficient plants which can give more yields even when cultivated on less land.

The conventional methods involve selecting and growing stress-resistant crops like cassava, millet and sunflower which can tolerate harsh conditions and survive from abiotic stresses. Tissue culture and breeding are included in other strategies where high yielding species can be crossed with stress tolerant crops to develop stress-tolerant high/yielding hybrids. Biotechnology can also prove to be another good strategy in this direction for more water-efficient and large-scale production methods in agricultural system using advanced tools like whole genome sequencing, physical mapping, genetics and functional genomics. Hence, different disciplines should work in an integrated way to target complex problems caused by different stresses and come out with an effective strategy to overcome the harsh effects. Thus, selection of good germplasm, identification of molecular mechanisms underlying tolerant and sensitive genotypes, molecular breeding methods of selection, transformation with specific genes and functional analysis are some of the important steps to be followed for crop improvement. Tobacco, tomato, maize *Arabidopsis thaliana, Brassica napus*, rice, wheat, cotton and oilseed rape are a few examples where genetic engineering has been used to develop high yielding GM crops tolerant towards abiotic stresses.

Adaptation for biotic stresses

Various types of resistant varieties against insects, fungi, bacteria and virus have been identified by conventional, molecular breeding and genetic engineering initiatives to combat the biotic stresses. Development of *Bt* crops like Bt maize, Bt cotton using *Bt* gene from *Bacillus thuringiensis* bacteria has been found to be a very promising strategy for integrated pest management program and thus proved to be very useful for the farmers. Further, transgenic canola (oilseed rape) and soybean were developed for herbicide resistance. GM cassava, bananas, potatoes and other crops resistant to bacteria, viruses and fungi have also been developed using advanced tools and techniques. Biotic stress-resistant GM crops raised the average yield of canola and maize upto 11-12% in comparison to conventional crop during 2002-2005 (Siwar et al., 2013).

CONCLUSION

This is a well known fact that climate variation is due to direct and indirect anthropogenic activities. Development and application of integrated approaches and strategies of different disciplines and use of new tools and techniques can play a major towards climate change mitigation and adaptation. Carbon sequestration, reduction in CO_2 emissions, reduction in use of fuel and artificial fertilizer, promotion for usage of biofuels are very important for improving soil fertility, crop adaptability, enhancing agricultural productivity in addition to providing safe and clean environment and ultimately reduce climate change.

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