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Impact and Breeding Approaches for Climate Change

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SUMMARY

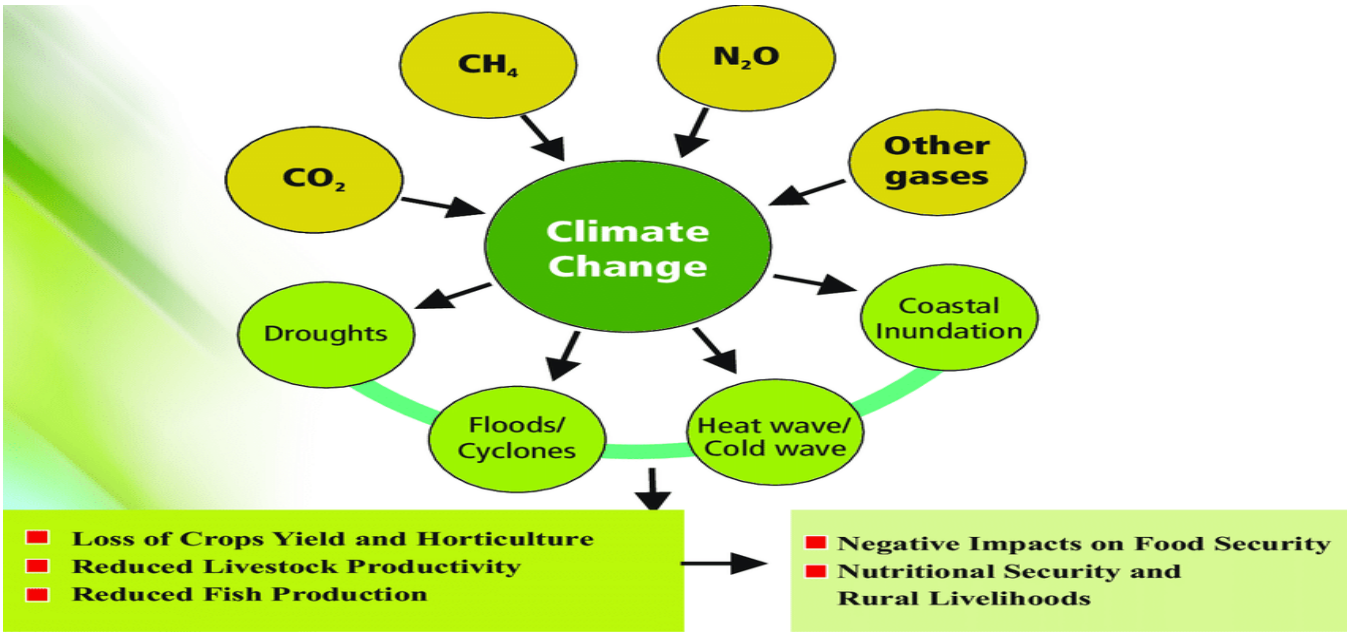
Climate change and agriculture are interconnected processes and both take place on a global level. Climate change affects agriculture in a number of ways viz., change in average temperature, rainfall, sunlight, change in atmospheric carbon dioxide and ozone concentration, etc. as a result of which changes have occurred in pest scenario, disease situation, water availability, day length, biodiversity, cropping pattern and in nutritional quality also.

INTRODUCTION

According to Intergovernmental Panel on Climate Change (IPCC), global temperature may be rise from 1.7 to 4.8°C during the twenty-first century and precipitation patterns will also be altered (IPCC 2014). The increasing pace of climate change, combined with the growing population and income growth, threatens food security across the globe. Agriculture is extremely vulnerable to climate change. The higher temperature eventually reduces crop yields whereas encourages weed and pest proliferation. Pests management has become less effective and higher rates of pesticides are needed to achieve the same levels of control. Heatwaves cause extreme heat stress in crops and limits yields if they occur during certain times of the plants' life-cycle (pollination, pod and fruit set). Also, heat waves can result in wilted plants (due to elevated transpiration rates) which can cause yield loss if not counteracted by irrigation. Heavy rains that often result in flooding can also be detrimental to crops and soil structure. Most plants cannot survive in prolonged waterlogged conditions because of anaerobic conditions. Hence, the overall impact of climate change on agriculture is negative, threatening global food security and also reducing farmer income.

Breeding Approaches for climate change

Plant breeding is a continuous process that helps in converging desirable traits in a genotype over generations/a period. Plant Breeding has always played a pivotal role in human history from revolutionizing agriculture to feeding the ever-growing population. The key role of plant breeding in agriculture is to develop a genetically superior genotype or variety, which is suitable for a specific as well as general cultivation of a particular environment towards higherproduction. Traditional breeding approaches such as introduction, selection hybridization and mutation played a key role in developing the improved genotypes for specific stress conditions.



Development of MAR lines

Development of crop cultivar with multiple adversities resistance. This includes breeding for multiple insect resistance (MIR) and breeding for multiple disease resistance (MDR). K. Dutta, 2002 developed such type of rice line resistance to bacterial blight, yellow stem borer and sheath blight disease.

Genetic Enhancement

Pre-breeding is an opportunity to introgress desirable genes, from wild species (primary, secondary and tertiary gene pools) into elite breeding lines/cultivars/genotypes, to overcome the linkage drag.The wild relatives (CWRs) are the good reservoir of untapped genetic variability,which may not exist in the cultivated gene pool and that can be exploited to improve various traits of interest including resistance/tolerance against diseases, pests, drought, salinity, cold, heat and good agronomic adaption with added quality.This technique can be used in developing novel genetic diversity that can be used in breeding crop cultivars suitable for climate change.

Transgenic breeding

Transgenic breeding can also be usedsuccessfully for developing crop cultivar resistance to disease, insect and drought conditions arising due to climate changes. Bt. Cotton is a genetically modified organism (GMO) or genetically modified pest resistance cotton variety that can produce an insecticide to combat bollworm. American bollworm causes yield reduction up to 40 – 70% under severe incidence but Bt transgenic cotton which can control the bollworms (M. Manickam).

Crop adaptation

Maintaining the sustainability of food production under climate changes requires the breeding of new crop verities better adapted to these condition. Heterogeneous crops exhibit greater stability across the environment. Adaptation is also about the development of early maturing, drought and heat tolerant cultivars under climate change to sustain productivity. The new cultivars would increase the production per unit area under moisture stress and extreme temperatures (Deressa, 2009).

Smart breeding approaches for climate change

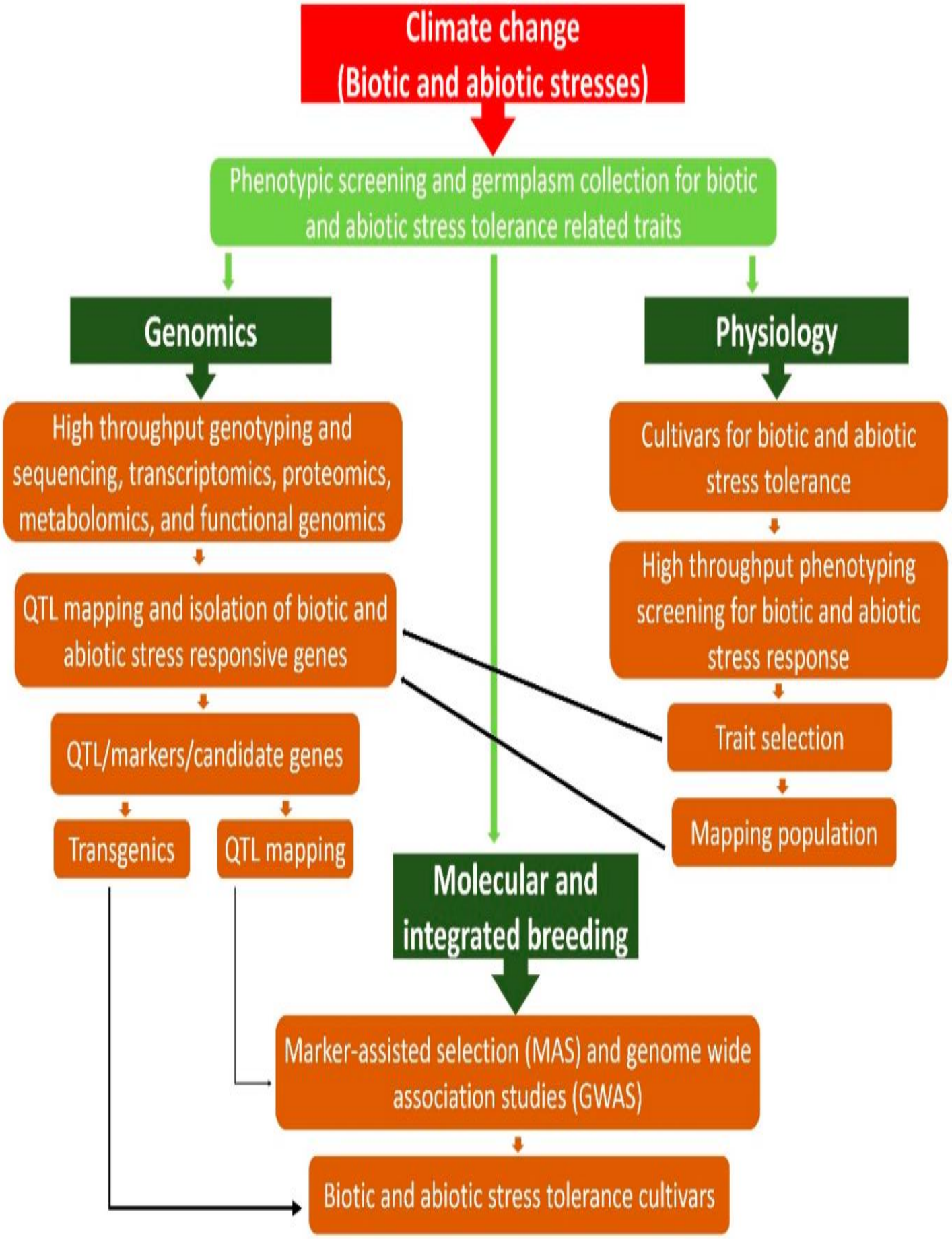
The concept of smart breeding is an integration of conventional breeding strategies with advanced molecular, genomic and phenomic tools to efficiently and effectively breed resilient crop cultivars with enhanced yield potential. New breeding approaches such as rapid generation advancement, doubled haploid (DH), marker-assisted backcrossing (MABC), marker assisted recurrent selection (MARS), genomic selection (GS), etc. have been used to help shorten the breeding cycle along with efficient screening for specific biotic and abiotic stresses.

Future Breeding Goals

Climate change affects things globally and India is also facing a climate change of considerable magnitude. Indian agriculture is divided into two main seasons: Kharif and Rabi based on the monsoon. It is reported that overall temperature rise is likely to be much higher during winter (rabi) rather than in the rainy season (kharif). Moreover, it is predicted that the mean temperature in India will rise by 0.4-2.0°C in Kharif and 1.1-4.5°C in Rabi by 2070 (Ruchita and Rohit, 2017).

A view of the climate change in india, future plant breeding efforts need to be directed towards the following thrust area.

- The new crop verities should be tolerant to drought and heat.
- The new verities especially grow during the winter season should have characteristics of early flowering, photo and thermo insensitivity, early maturity and high productivity.
- Landraces should be used in the breeding program for developing varieties suitable for climate change.
- Development of new cultivar using a combination of conventional and breeding approaches *viz.*, MAS, genome editing, genomic selection, induced mutation and transgenic breeding. Crop based coordinated programs need to be launched to develop early maturing, high yielding, temperature and drought-tolerant verities as early as possible


Climate change
(Biotic and abiotic stresses)
Phenotypic screening and germplasm collection for biotic and abiotic stress tolerance related traits
Genomics
Physiology
High throughput genotyping and sequencing, transcriptomics, proteomics, metabolomics, and functional genomics
Cultivars for biotic and abiotic stress tolerance
QTL mapping and isolation of biotic and abiotic stress responsive genes
High throughput phenotyping screening for biotic and abiotic stress response
QTL/markers/candidate genes
Trait selection
Mapping population
Transgenics
QTL mapping
Molecular and integrated breeding
Marker-assisted selection (MAS) and genome wide association studies (GWAS)
Biotic and abiotic stress tolerance cultivars

CONCLUSION

The altimate result of climate change on agriculture and human well-being will be negatively affected. Crop yield will decline, production will be affected, crop prices will increases hence consumption of cereals will fall, leading to reduce calorie intake and increase malnutrition. Hence, the overall impact of climate change on agriculture is negative, threatening global food security and also reducing farmer income.

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