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Review Article

CROP IMPROVEMENT THROUGH DIFFERENT MEANS TO ADDRESS CLIMATE CHANGE AND FOOD SECURITY

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Abstract *This study evaluated several crop development techniques in addition to the effects of climate change on productivity in agriculture. Climate affects agricultural productivity and the distribution of crops worldwide. Given the current and projected variations in temperature, precipitation, and carbon dioxide concentrations, it is unclear whether agroecosystems will be able to produce enough food to meet the world's needs. Crop output, water productivity, and soil water balance are frequently altered by climate change. Soil moisture content and groundwater levels will be affected by the immediate effects of global warming-induced changes in temperature and precipitation patterns. Agricultural output is affected by several factors, such as crop variety, growing circumstances, soil deterioration, and water availability. Modern agricultural systems use genetics, biotechnology, plant breeding, environmental monitoring, and adjustments to management techniques to adapt to climate change. On the other hand, without a more thorough approach to agricultural systems, development cannot proceed. A strategy like this would mean growing amounts of a wider variety of superior crops and advancing equity, sustainability, nutrition, and food security in the future.*

Keywords: *climate change; food security; crop improvement; sustainability; genetics*

Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimates that 70% more food must be produced over the next 40 years to feed a human population that is expected to exceed 9 billion by 2050 (Searchinger et al., 2014). This is because the rate of increase in the world's population has outpaced the linear progress in food production. Climate change and changes in agricultural production methods make achieving such an enormous gain which would require a 37% increase in annual food supply over the previous linear increases much less likely (Bruinsma, 2017).

It is commonly acknowledged that future food security faces significant risks due to climate change. Although it is impossible to predict the exact effects, it is generally agreed that climate change will harm the world's food production (Dawson et al., 2016; Fischer, 2009; McKenzie & Williams, 2015). Increased CO_2 and temperature, diseases and infestations, lower head and milling yield, and declining quality attributes can all have negative consequences (Prior et al., 2011). Climate change is causing extreme weather events, like droughts and flooding, to happen more frequently (Sage & Coleman, 2001). Future food security is thus threatened by four factors: growing demand, declining supply, and the need for resilient and sustainable production (Alonso et al., 2018). Furthermore, because of how these factors interact and support one another, it is expected that the overall burden of food insecurity will rise, requiring a change in the food system (Cole et al., 2018).

The scope of the problem

Recurring floods and droughts are two catastrophic effects that extreme weather patterns can have on agricultural output and, consequently, food security.

Using statistics from the United Nations Intergovernmental Panel on Climate Change (IPCC), (Nelson et al., 2010) determined that an additional 40 to 170 million people will experience inadequacy due to climate change. Almost everyone agrees that the twenty-first century will bring extreme weather occurrences to many parts of the world (Misselhorn et al., 2012), such as heat waves, heavy precipitation, and increasing sea levels; salinity, drought, and flooding will be the main effects. The methods used to overcome these limitations vary geographically, much like the kinds and sizes of problems they address. For example, while it is widely agreed upon that global annual precipitation will rise, other areas will see a decrease in this amount. In addition, the seasonality of precipitation will affect when crops are planted. Even more concerning is the projection that extreme weather events occur more frequently and last longer (Gibson, 2012). It will be difficult to maintain the current rate of productivity increase in the future due to limitations inherent to the industry. However, there is a chance that the current pace of yield growth will not be sufficient to meet the future demand for grain commodities (Helms, 2004). In comparison to the previous annual yield growth pattern, the majority of studies that compute the yearly output increase required to fulfill demand predict a necessity for an increase of more than 1% (Prosekov & Ivanova, 2018).

A scenario where demand surpasses supply may lead to a reappearance of malnutrition, ultimately impeding efforts to finally eradicate world hunger. Furthermore, even in scenarios where supply and demand are comparatively in balance, abrupt changes in the climate and environment may reduce the incentives for investments in food systems and jeopardize food security. Climate change and increasing demand may have a major influence on food security in the future, which could impede or reverse the progress made toward the global abolition of famine (Berry et al., 2015).

In this context, new research indicates that the inadequate nature of present food production techniques calls for a reform of the food system. Future food availability could be improved through the following means: changing one's diet (Campbell et al., 2016), eliminating food waste (Ericksen et al., 2009), applying improved agronomic practices to close yield gaps (Premanandh, 2011), increasing the amount of arable land (Mc Carthy et al., 2018), and increasing productivity (Ingram, 2011). The creation and application of new technology (precision agriculture, new crop types, etc.) are essential to raising production. New technologies often face barriers to their adoption and growth, particularly in developing countries, which limits their potential to improve food security.

How climate is changing Day by day?

Elevated severe event levels, increased global event frequency, and enhanced intensity are all indicators of climate change (IPCC, 2013). Over the past 800,000 years, the quantities of methane, carbon dioxide (CO2), and nitrous oxide (NOx) in the atmosphere have reached all-time highs. The previously unanticipated increases in greenhouse gas emissions are responsible for these growing trends (Ahad & Reshi, 2015). Figure 1 presents the environmental outcomes of climate change

Figure 1: Different outcomes of climate change which are affecting the global environment

Temperature

Climate change is a worldwide concern since its effects are not uniform, even if it has global implications. Therefore, it is imperative to understand the diverse ways in which different places will be impacted by climate change. In addition, the forecasts show that worldwide temperatures will rise steadily between 2016 and 2035, with land areas rising faster than oceans, tropics, and subtropics surpassing mid-latitudes, and hot extremes becoming more commonplace while seasonal and daily cold extremes decline. Over the next 2100 years, the Arctic is expected to have temperature increases of 1.5 °C, which is greater than the average global surface temperature (Gautam et al., 2013).

Precipitation

Temperature variations will have a direct impact on precipitation patterns during the next 80 years. The expectation is that by the end of the century, mean precipitation will decrease in many arid mid-latitude and subtropical regions while increasing in many wet mid-latitude regions. Furthermore, by the end of the century, it is predicted that extreme precipitation events will become more frequent and intense throughout most of the mid-latitude land masses, including tropical regions that get significant amounts of moisture (Gray & Brady, 2016).

Effect on agriculture

These forecasts show how the worldwide agricultural output—across all crop-growing regions is affected by climate change. Increased yearly temperatures, rising carbon dioxide concentrations, and altered precipitation patterns all pose a threat to food security and precipitation patterns, which will have an impact on all aspects of agriculture (Rehman et al., 2015).

Minerals in the soil

Agricultural productivity is dependent on soil quality since crop yield and soil quality are closely related. Since the beginning of the development of arable land, human activity has had an impact on soil resources (Raza et al., 2019). Even in the absence of certain climatic conditions, land conversion, deforestation, tillage, and excessive chemical use all contribute to soil deterioration. In contrast, a recent special report by the Intergovernmental Panel on Climate Change states that the effects of climate change cause new patterns of land degradation as well as speed up and intensify some already-occurring land degradation processes (Brouder & Volenec, 2008). Two main areas of investigation are soil erosion and the behavior of soil surface water.

Water availability is impacted by climatic changes

It is well acknowledged that the availability of water directly affects human prosperity and agricultural productivity. Encompassing the natural replenishment of surface and groundwater resources, the hydrological cycle is significant for global agriculture, hydroelectric power generation, and water supply (Hatfield, 2013). The amount of water that can be diverted, the amount that can be stored in surface and groundwater reservoirs, and the availability of water all affect its availability. In addition to being essential for protecting the ecosystem, human life, and biodiversity, an analysis of seasonal and long-term water availability also gives water authorities and farmers useful data for managing and distributing agricultural water. The hydrological cycle is significantly impacted by changes in land use, pollution, population growth, and climate change (Dusenge et al., 2019). One possible effect of climate change is less precipitation in some areas, which might put water resources at risk. Given the uncertainties surrounding climate variability, water demand, and the socioeconomic and environmental consequences, it is critical to put policies into place that maximize the use of the limited water supply and generate new water resources (Hatfield & Prueger, 2015). If snowmelt and buildup help to replenish water stocks, the water system's vulnerability to climate change would increase.

Climate change's effects on agricultural productivity

Variations in temperature in climate-related factors influencing agricultural yields could have a major impact on food supply both locally and globally (Hatfield et al., 2011). Crop growth simulation models or experimental data can be used to evaluate the possible effects of climate change on agricultural productivity. Crop models provide useful tools for predicting future effects on agricultural output. Many crop simulation models have been used extensively to investigate how climatic variability may affect crop productivity, with an emphasis on how crop yield is sensitive to various climate scenarios. These models are called CERES-Maize (Crop Environment Resource Synthesis), CERES-Wheat, and SWAP (Soil, Water, Atmosphere, Plant) (DaMatta et al., 2010).

There is a relationship between crop water production and climate change.
The main goal of global agriculture in the twenty-first century is to produce more food to feed the growing population while managing the limited water resources it has access to wisely (DaMatta et al., 2010). Crop water production may be increased to do this (Chakraborty et al., 2000). Water productivity, which refers to the monetary benefit or value that results from the use of water, is a crucial component of water governance and includes the supply of water to arid and semi-arid regions. Reducing water use while maintaining yield levels and optimizing water use to increase crop yields are the two possible approaches for improving water productivity (Korres et al., 2016).

Climate change affects the homeostasis of soil and water

Soil water balance plays a major role in water management and water consumption planning. Plant transpiration and soil evaporation will be impacted by temperature and precipitation variations brought on by climate change. According to the Intergovernmental Panel on Climate Change's Fourth Assessment Report (IPCC AR4) (Korres et al., 2016), average yearly precipitation will decrease in the subtropics and increase in high northern latitudes and tropical regions.

Effects of climate change on food security

The Food and Agriculture Organization (FAO) defines food security as "the state in which all individuals, without exception, have economic, social, and physical access to an adequate supply of safe and nutritious food that satisfies their dietary requirements and preferences for living an active and healthy lifestyle at all times." The concept of food security is comprised of four elements, namely food availability, food stability, food access, and food consumption (Rezaei et al., 2023). However, the majority of the studies that have already been done have focused on how climate change affects the availability of food, with little thought paid to the possible consequences of increased climatic variability, the frequency and intensity of extreme events, and food stability. According to the FAO (Rezaei et al., 2023), the use of biotechnology can improve food security and reduce environmental stress at the same time. On the other hand, altered crop types may increase the amount of land that can be farmed, even in cases where the soil has deteriorated, which would increase the amount of food that is available in the future. These crops are unaffected by salinity, severe weather, drought, and waterlogging.

Enhancement of the main crop is necessary

Regardless of the improvements made, there will be fewer fallow periods and, as a result, decreased soil fertility as the human population and demand for land grow. The cost of fertilizers will rise in lockstep with the price of fossil fuels, but their viability in the Pacific will be constrained by isolation and high shipping costs. Indigenous populations have already established themselves on the most fertile soils in the majority of PICs (Dixon, 2012). Due to the limited supply of new farmland, agroecologically efficient systems with higher crop production will produce more food overall. Developing new varieties that can provide higher yields with currently limited inputs is essential to improving the overall resilience of the food system. It's common knowledge that excellent cultivars, with their low input needs, provide the best return on investment. Therefore, under these conditions, the best ways to promote adaptability and increase cropping systems' overall flexibility are seen to be the adoption of new varieties and plant genetic development. The SPC organizes regional meetings of agricultural leaders where regular updates and needs assessments are carried out (Wang et al., 2018).

Genetic advancements for crops yield

The genetic makeup of the crops and the techniques used in agronomic management are two key factors that interact intricately and contribute about equally to crop yields (Malhi et al., 2021). Genetic innovations contributed, on average, between 50% and 60% of the gains in maize on-farm yields that occurred in the United States over the previous seven decades (Luo, 2011). Genetic innovations resulting from the application of the capacities found in the genetic blueprints of plant genetic resources for food and agriculture (PGRFA) may be extremely beneficial to attain the required 70% increase in food production.

Genetic innovations have had a significant impact on agricultural yields, as demonstrated by the creation and widespread use of hardy, high-yielding cereal crop types during the Green Revolution, which began in the late 1960s. Many people hold the view that the significant increases in food production that ensued in many nations facing food scarcity saved billions of people, mostly in Asia (Ben Mariem et al., 2021). The introduction of New Rice for Africa (NERICA) cultivars, which are recognized for their excellent yields, has been credited with driving significant growth in rice farming in Sub-Saharan Africa in recent years (Long & Ort, 2010). Plant breeding is the science of modifying a plant's heritable traits to increase a plant's market value (Bailey-Serres et al., 2019). Against this backdrop, "plant breeding employing both traditional and innovative methods to enhance yields, improve efficiencies in terms of water, nutrients, and other inputs" as a means of overcoming the significant challenges involved in raising food production while also lowering environmental impact. Better crop cultivars with improved agronomic and quality traits were consequently produced. To alleviate the problems associated with food scarcity, the World Economic Forum prioritized the development of innovative crop types through partnerships with global businesses. This study contributes to the continuing discussion about how to improve plant breeding's capacity for adaptation in the face of these difficulties. We highlight some of the creative partnerships, research, technology, and policy initiatives that could help national programs—especially those in poor countries—implement goal-oriented, responsive agricultural reform programs (Hamdan et al., 2022).

An approach to mitigate yield inequalities by integrating genetics, environment, and management

Considering the intricate relationship between genetics (G), management (M), and environment (E) that governs the development of crops, these emerging technologies can be employed to evaluate present circumstances and furnish substantiation for the effectiveness of adaptive management approaches. G x E x M, as described by Hatfield and Walthall (2015), posits that to ensure sufficient food production to sustain the entire planet by 2050, it is imperative to reduce the yield disparity.

Induced mutations

When it becomes challenging or impossible to obtain heritable variants from existing germplasm, allelic variation induction becomes an attractive alternative. Figure 2 presents induced mutation breeding.

Mutation, which refers to heritable alterations to the genetic code, has served as the primary catalyst for evolution, leading to the domestication of crops and animals, in addition to speciation. Physical and chemical agents have been employed by scientists to induce mutations in plants ever since the groundbreaking identification of X-rays and other forms of radiation in the early 20th century (Suprasanna et al., 2015), followed by subsequent evidence that they can permanently alter genetic material. As a consequence, induced mutation has been recognized as a successful strategy for enhancing crops, leading to the development of more than 3,200 officially acknowledged elite crop varieties and aesthetically pleasing plants cultivated globally (Ahloowalia & Maluszynski, 2001).
To increase the likelihood of success, scientists have conventionally increased the quantity of putative mutants they generate and subsequently examine, given that mutation is a stochastic process. The principal motivation for exploring alternative methods to exploit heritable variations in crops is the laborious and expensive nature of this approach, in addition to the tediousness involved. Presently, biotechnology applications are being implemented to increase the efficacy of large-scale population production and evaluation. Targeted Induced Local Lesions IN Genomes (TILLING) is a high throughput reverse genetics technique (BABAR et al., 2022) that enables rapid screening of large populations of plants for specific mutation events. Due to its efficacy and sensitivity in identifying mutations in pre-selected genomic regions, TILLING is an extremely promising technique for increasing the genetic diversity of crops via induced mutations.

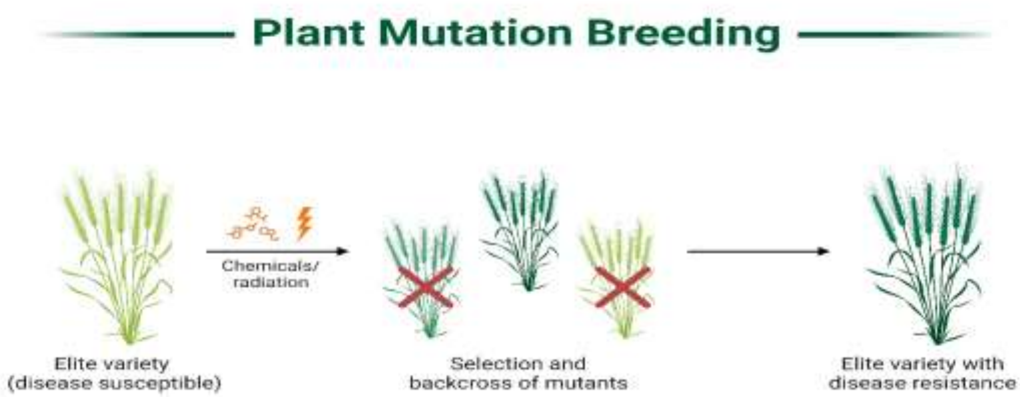

Figure 2: Induced mutation in plant breeding

Innovative methods of plant reproduction

The potential for significant advancements in biotechnology to enhance agriculture is readily apparent (abu Haraira et al., 2022). Molecular breeding—the application of molecular biology techniques to plant breeding—can significantly transform plant breeding research and practice by increasing efficiencies. To enhance PGRFA, molecular breeding involves the utilization of recombinant deoxyribonucleic acid (DNA) techniques, which are also referred to as genetic transformation. Breeding materials are chosen based on diverse molecular profiles. Additional molecular biology-based technologies that have emerged in recent times exhibit the potential to enhance the efficacy of plant breeding endeavors. A concise synopsis of how these instruments and methodologies are employed in the development of novel cultivars of crops is furnished (Bhutta et al., 2023).

Double haplotype (DH)

Haplotype recovery and population doubling can be achieved utilizing pollen grains that stimulate chromosomal doubling in plants. Consequently, the time needed for line fixation is drastically reduced, as complete homozygous lines are generated in an imminent fashion (Khalid, Abdullah, et al., 2021). This is performed exclusively in tissue culture laboratories on cereal and rice species that are amenable to tissue culture cultivation. Analogous to RGA, this approach has been implemented in the field of rice breeding for an extensive duration (Khalid, Amjad, et al., 2021), yielding an immense assortment of rice varieties. Nevertheless, doubling haploid populations of the indica subspecies has proven more challenging for biological reasons than doubling haploid populations of the japonica subspecies.

Shuttle breeding

Nobel laureate Dr. Norman Borlaug popularized the shuttle breeding concept, which was initially devised by the wheat breeding program of the International Maize and Wheat Improvement Center (CIMMYT). By essentially selecting a new field area annually, this approach facilitated the advancement of an additional generation. Two distinct field locations in Mexico were utilized by the CIMMYT wheat shuttle breeding initiative to conduct off-season breeding operations. This approach also enhanced selection because field locations varied for a range of environmental conditions and diseases. The rice shuttle breeding program was commenced in 1982 (Khalid, Tahir, et al., 2021). With time, however, several practical obstacles arose in regards to the international transmission of seed, primarily attributable to concerns regarding intellectual property and the safeguarding of national germplasm. Notwithstanding these limitations, off-season nurseries are utilized by the private sector, particularly in temperate climates.

Methods employed in molecular breeding

The utilization of DNA (or molecular markers) as selection instruments in plant breeding has yielded substantial productivity gains and the introduction of novel cultivars (Misselhorn et al., 2012) over the past thirty years. In many cases, marker-based screening is more effective than conventional approaches, resulting in increased precision, time or financial savings, or the capability to detect conditions that conventional phenotyping techniques are incapable of identifying (Ahloowalia & Maluszynski, 2001). A key benefit of utilizing markers is their exceptional ability to precisely monitor (or detect) homozygosity. Molecular breeding has been extensively implemented in breeding programs of the private sector, where increased rates of genetic gain have been reported (Bailey-Serres et al., 2019). A multitude of accounts regarding the development of marker-assisted varieties have emerged as a result of the widespread implementation of marker-assisted selection (MAS) in major crop breeding programs (Ahad & Reshi, 2015).

Marker-assisted selection

The increasing availability of rapid, efficient, high-throughput, and cost-effective molecular biology technologies for tracing inheritance and identifying the origins of desirable traits is transforming the fields of plant breeding and PGRFA management. The emergence of genomics can be attributed to advancements in molecular biology that have reduced the cost of whole-genome sequencing. The availability of a substantial quantity of information and assaying instruments about the complete genetic composition, or genome, of an individual, has ensued. The related sciences of proteomics (study of proteins) and metabolomics (study of metabolites), which are enabled by an ever-increasing volume of publicly available DNA, gene, and protein sequence data, contribute to novel approaches to comprehending trait inheritance. Prominent developments in the fields of bioinformatics and computational molecular biology have facilitated reliable outcomes in the characterization of germplasm, evaluation of genetic diversity, and selection of breeding material. New, extraordinarily complex, and potent information technology systems that store and analyze the enormous quantities of data produced by molecular biology procedures are largely responsible for these developments (Xu & Crouch, 2008).

The ability to precisely identify these "landmarks" on the genome through the application of statistical algorithms has brought about a paradigm shift in plant breeding and will be indispensable in the advancement of "smart" crops in the coming decades. The capability to identify molecular markers, which are segments of the genome that distinguish individuals, through the application of appropriate scientific methods, has irrevocably transformed plant breeding. In the plant breeding method referred to as marker-assisted (or -aided) selection (MAS), molecular markers have become the instruments of choice for observing the inheritance of target genomic regions in breeding materials (Ejeta & Knoll, 2007).

Genetic modifications

The technology of recombinant DNA has emerged as a valuable instrument for the improvement of agriculture. Novel genetic variation is produced through the fusion of molecules transporting DNA sequences originating from multiple sources. The modifications that ensue are referred to as transgenics or GMOs (genetically modified organisms). Figure 3 presents some GMO crops. The term for this procedure is genetic modification (or transformation). By utilizing vectors or biolistics to insert exogenous DNA or ribonucleic acid (RNA) sequences into the genome of the receiving organism, novel and agronomically beneficial traits are introduced into existence. Four crops—corn, soybean, canola, and cotton—have been cultivated commercially using transgenic cultivars carrying two transformation events—herbicide tolerance and insect resistance, or their combinations—since the initial approvals in 1996 (Ejeta & Knoll, 2007).

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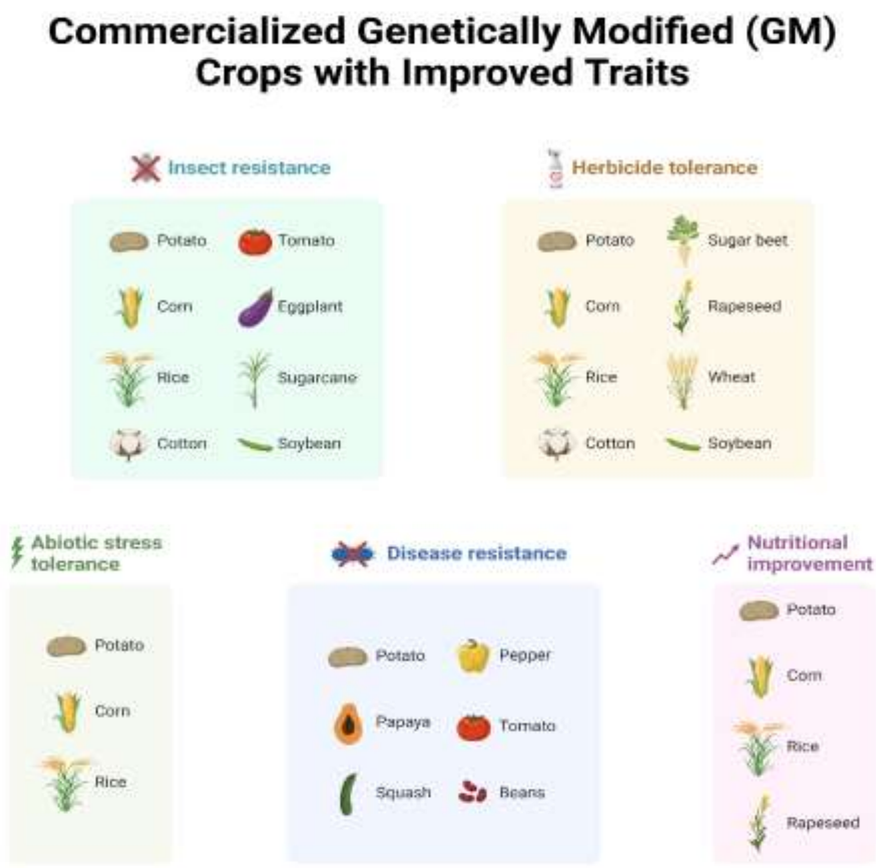

Figure 3: Different GMO crops produced globally

Selection of genomes

As the field of rice genomics advanced, molecular breeding strategies that utilized complete genomes surfaced. Recently, genomic selection (GS) has become an increasingly prominent technique (Boopathi & Boopathi, 2020). Genomic selection, as opposed to emphasizing particular genes or quantitative trait loci, functions as an adjunctive approach to multiple association sampling (MAS). Its methodology entails deriving genomic characteristics from a substantial quantity of DNA markers (Sebastian et al., 2010). In the past decade, maize, wheat, and rice experimental endeavors have produced encouraging outcomes about the reduction of breeding cycles and the acceleration of variety production times. Genomic selection holds considerable promise for the accurate selection of complex factors such as yield and for shortening the reproduction cycle to enhance the rate of genetic gain (Ben-Ari & Lavi, 2012). Nevertheless, the practical execution of public sector reproductive initiatives in developing nations is beset by substantial technological and financial barriers. Furthermore, before using genomic selection, the most cost-effective and efficient strategy must be evaluated (Boopathi, 2013).

New advancements in biotechnology

Crop improvement through the integration of biotechnologies is a swiftly expanding topic. In response to the European Commission's request "to provide information on the state of adoption and possible economic impact of new plant breeding techniques, According to the authors, the novel variations arising from these procedures could be available within three years. They discovered eight new methods of this type. These unique approaches' characteristics are as follows: ZFN, or zinc finger nuclease, is a protein that adds new genes to the genome or creates single mutations or brief indels at predetermined target loci (Hasan et al., 2021).

Oligonucleotide-directed mutagenesis, induces targeted alterations to one or more nucleotides. Genetically Modified Organisms (GMOs) are formed by inserting genetic components that are either contiguous and unaltered from the species or a

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cross-compatible species (cisgenesis). Alternatively, the inserted DNA could be a new combination of DNA pieces, but it must still originate from the same species or a cross-compatible species.
Modified gene expressions are still being produced; they are epigenetic, and the new phenotypes are passed down only after a few generations. Grafting non-transgenic scions onto GM rootstock produces the intended improvements. Inverted breeding combines recombinant DNA technologies and cell biology protocols to swiftly generate transgene-free homozygous parental lines suitable for reconstituting elite heterozygous genotypes (Hasan et al., 2021; Ragimekula et al., 2013).

Agricultural infiltration is a liquid suspension of Agrobacterium sp. The desired gene or genes are infiltrated into plant tissues, predominantly leaves, where they are highly expressed locally and transiently. This technique is typically utilized in research situations, such as studying plant-pathogen interactions in living tissues, selecting parental lines, or evaluating the efficiency of transgene (Liang et al., 2004). Artificial genomes: Large functional DNA molecules are generated artificially, with no natural templates, to construct functional minimal genomes that can serve as platforms for the biochemical synthesis of compounds such as pharmaceuticals and biofuels.

High-throughput analyses for phenotyping

It may be challenging to choose a small number of promising individuals from large populations of segregating materials. MAS has considerably enhanced the number of data points obtained per unit of time as well as the number of assays that may be done. To ensure complete process efficiency, phenotypic evaluations must be updated to match high-throughput molecular assays. Indeed, reliable phenotypic data must accompany molecular data used in breeding for the latter to be trusted (Shakoor et al., 2017). The study of phenomes is known as phenomics. The term used to describe the novel high-throughput measurements of an organism's physical and chemical features is the sum of an individual's phenotype. In this apparent connection to genomics, its term is a little vague, but according to (Yang et al., 2020), it is "the acquisition of high-dimensional phenotypic data on an organism-wide scale." High throughput imaging of living plant parts, such as roots and leaves, using thermal infrared, near-infrared, fluorescence, and even magnetic resonance imaging, allows for non-destructive physiological, morphological, and biochemical assays. Complex features, such as salinity and drought tolerance, can be broken down into their component qualities (Araus & Cairns, 2014). Phenomics facilities are increasingly being established, and many of them are now providing high throughput phenotyping services to requestors, although fundamental technological difficulties, such as data management, remain unresolved. Developing countries may not have long to obtain access to these platforms due to high establishment costs and technical competence.

Conclusion

The availability of food is facing significant challenges due to population growth, climate change, and economic expansion, which means that current methods of food production will not be adequate to meet future food demand. Plant breeding, which has historically been a major factor in reducing hunger, is usually associated with protracted production processes that must adapt to quickly shifting market, environmental, and climatic conditions. We contend that to maintain plant breeding's position as the primary source of food security and to make it more adaptable to ever-changing goals, the breeding process must be accelerated.

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All authors contributed equally.