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Review Article

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Emphasis of Plant Breeding in the Climate Impacts

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ABSTRACT

Plant breeding has been made a crucial role in food and agriculture by studying and focusing on utilization of genetic diversity of plant's adaptability and survival when their environments change. Plant breeding efforts to help producers overcome the enormous challenges posed by climate change through the creation of new seed varieties with improved genetics from germplasm exhibiting stress tolerance. This field plays a decisive role in advancing crop varieties and hybrids to become more productive, high in quality, and better adapted to abiotic and biotic stresses, as well as producing plants that can contribute to reducing greenhouse gas emissions by increasing nitrogen and CO2 input-use efficiency. However, with global temperatures rising, the human population, absence of urgent institute measures, limited application of new methods, lack of resources, training and capabilities, more frequent and severe drought and flooding, along with increased pressure from insects and disease, will be agriculture's biggest challenge. On the other hand, there are great opportunities to overcome earlier mentioned problems. For instance, advances in technology have put many more tools into breeders' hands. Technologies like molecular markers and bioinformatics and other techniques are expediting the process of analyzing and assessing traits.

Keywords: *Plant breeding, Climate change, Food and Agriculture, Crops.*

INTRODUCTION

Plant breeding for these purposes is essential to ensure food safety, nutrition, and the health of people and the environment. They are essential to the long-term viability of production systems. Crops, livestock, aquatic organisms, and forest trees can withstand a wide range of harsh conditions because their genetic resources are studied and conserved. Because of plant breeding, which is the study and utilization of plant genetic diversity, plants are better able to adapt and survive when their environments shift. As early as the nineteenth century, climate change was recognized as a problem, but until the first World Climate Conference in 1979, the issue was not on the international scientific or political agenda (Gupta, 2010).

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At the Rio Earth Summit in 1992, the United Nations Framework Convention on Climate Change (UNFCCC) was established as the first international agreement to address climate change (UNFCCC). Despite this, the importance of plant breeding and genetic resources for food and agriculture has been overlooked in the UNFCCC process. Although forests have been discussed in the context of climate change mitigation, forest genetic resources have not been specifically mentioned.

Similarly, crop and livestock genetic resources, aquatic genetic resources, micro-organisms and invertebrates have been largely absent from the UNFCCC policy debate. Genetic resources for food and agriculture are largely ignored because of the UNFCCC's focus on mitigation. Historically, the UNFCCC has prioritized reducing greenhouse gas emissions (Burton, 2008). There has been an increase in UNFCCC decision-making on climate change adaptation (i.e. activities aimed at reducing vulnerability and building resilience) and new funding mechanisms to support this work in recent years.

New seed varieties with improved genetics from germplasm showing stress tolerance are being developed in plant breeding to help farmers overcome the enormous challenges posed by climate change. Although the European Seed Association claims that global temperatures could rise by 11 degrees Celsius by 2050 due to climate change, the report also states that increased pressure from insects and diseases, along with more frequent and severe droughts or floods, will be agriculture's greatest challenge. Wayne Smith, chair of the National Association of Plant Breeders Communications Committee, says that "if increased temperatures, reduced rainfall, and changing rainfall patterns become the norm, then the issue becomes one of either the need for better breeding selection methodology or producers changing crop enterprises," he says.

There is a pressing need for improvements in both in situ and ex situ conservation programmes for domesticated species, their wild relatives, and other wild genetic resources important for food and agriculture. Millions of people who depend on agriculture, aquaculture, fishing, forestry, and livestock for their livelihoods and food security are likely to experience climate change on a scale they have never seen before in the next several decades. We must have plants and animals that have the ability to quickly adapt to these new conditions if we are to meet the challenges these changes pose. Ecological processes and ecosystem services, a variety of breeds, strains, and species, and diversification in management strategies will be increasingly important in production systems if they are to be sustainable and productive (Galluzzi et al., 2011).

As a result of technological advancements, breeders now have access to a wider range of tools. According to American Seed Trade Association CEO Andy LaVigne, new technologies like molecular markers and bioinformatics are speeding up the process of analyzing and assessing traits. Crop varieties and hybrids that are more resistant to biotic and abiotic stresses, as well as plants that can help reduce greenhouse gas emissions by increasing nitrogen and CO2 input-use efficiency, will all benefit from advances in breeding techniques in the future. Because breeders can now look at their library and tease out a specific trait they previously could not, LaVigne says, "Traits that may not have been as attractive 10, 15 or 20 years ago are more important today" (FAO, 2010).

Climate change impacts on plant breeding for food and agriculture, and this review paper aims to highlight some of the current knowledge on this topic, as well as discuss the potential roles of plant breeding technology tools in the adaptation and mitigation of climate change, and identify future research areas to solve production problems in a changing environment that is dwindling at an alarming pace.

2.1Climate Change's Effect on Agriculture

The agricultural sector is particularly vulnerable to the effects of global warming. The spread of weeds, diseases, and pests is aided by higher temperatures, reducing crop yields in the long run. There is an increased risk of crop failure and long-term production declines due to changes in precipitation patterns. Climate change is expected to have a negative impact on agriculture, threatening global food security, despite gains in some crops in some regions of the world (Nelson et al., 2009).

2.2 Climate change and food security

Changes in the climate are expected to have a negative effect on food production, food quality, and food security. Table 1 shows that by 2080, the number of undernourished people will have increased 1.5 times in the Near East and North Africa, and 3 times in sub-Saharan Africa, compared to 1990 (Tubiello & Fischer, 2007). If early warning systems and development programmes aren't used more effectively, climate change will worsen food insecurity (Brown & Funk, 2008). To this day, the food they produce feeds millions of hungry people. Climate change could lead to an increase in hunger if it reduces food production while population growth continues. According to Lobell et al. (2008), climate change in semi-arid regions is expected to reduce the yields of cereal crops such as maize, wheat, and rice over the next two decades. Food security around the world could suffer as a result of these changes.

2.3 Role of Plant breeding in coping with climate change

Plant breeders have focused their efforts on increasing the yield of varieties, improving their resistance to environmental stressors, and improving their ability to tolerate environmental stress for many years now. Other factors that have been improved for the benefit of mankind include: ripeness, flavour, size, nutritional and crop quality, firmness, shelf life, plant type, labour costs, and harvestability. Unfortunately, this seminar paper will not be able to cover all of the current contributions of plant breeding to global food and agriculture. As a result, the following are brief descriptions of a few of the contributions.

A. Yield

The yield is perhaps the most critical of all the characteristics. Many years of research in various crops have shown an increase in yield of 1% to 3% per year. 1% may not seem like much, but over the course of many years, it adds up to a substantial sum. A yield increase of around 1% per year, or around 100 kilogrammes per hectare, has been achieved in irrigated wheat over the last 30 years (Pingali & Rajaram, 1999). From 1960 to 2000, wheat yields increased by 208 per cent; rice yields increased by 109 per cent; maize yields increased by 157 per cent; potato yields increased by 78 per cent, and cassava yields increased by 36 per cent (FAOSTAT).

Over the past 60 years, UK winter wheat yields have more than tripled from 2.5tonnes/hectare to 8tonnes/hectare. Researchers at the National Institute of Agricultural Botany (NIAB) in the United Kingdom (UK) conducted a study in 2008 involving 3,600 trials of 300 varieties of wheat, barley, and oats, resulting in 53,000 data points. Studies have shown that between 1947 and 1986, plant breeding was responsible for half of the increase in yield; the other half was due to advancements in fertilizer, crop protection products, and farm machinery. Over 90% of the increase in yields between 1982 and 2007 can be attributed to the introduction of new varieties, according to a 2008 study. This clearly demonstrates the role of genetics in increasing yields.

B. Land Ignored

Plant breeders have contributed to a reduction in the amount of land needed to achieve the same level of production by steadily increasing yield. India's cereal production, for example, increased from 87 million metric tonnes in 1961 to 200 million metric tonnes in 1992 on a nearly constant arable land base, helping to limit land use expansion. While the population grew from 2.5 billion to 5.5 billion between 1950 and 2001, the amount of land dedicated to farming stayed the same at around 1.4 billion hectares. 26 million square kilometres of land have been saved, and this number is expected to grow in the future (CLI, 2001).

There has been a decrease in deforestation and an increase in biodiversity as a result.

C. Tolerant to Stress Resistances

More than 85 billion US dollars are lost each year due to pathogens, and 46 billion dollars is lost due to insects. As a result, breeding for biotic stress resistance is becoming increasingly important. In this context, resistance to pathogens such as nematodes, viruses, fungi, bacteria, and water moulds is included. Many new varieties have been developed over the years that are more resistant to disease. Thus, farmers have been able to ensure that they have enough food at the end of the growing season through this method. The use of crop protection products has been significantly reduced as a result of this biotic stress resistance breeding, reducing agriculture's overall environmental impact. Disease resistance saves the British economy an estimated $100 million a year in crop protection products (BSPB, 2009).

However, it should be noted that much work remains to be done. In the case of Fusarium head blight (FHB), ergot, and stem rust, three fungal diseases that affect cereals and grasses, it is still necessary to develop fully resistant varieties. FHB is estimated to cause a loss of $1 billion in wheat yield and grain quality each year, according to estimates. Ergot infection has been linked to wheat losses of up to 10% in North Dakota (US) and rye losses of up to 5% in the state. Crop losses have been reported at 100% with the Ug99 strain of stem rust. These are just a few examples of how plant breeders desperately need these areas.

D. Tolerance to biotic stress

Drought affects 90 million people yearly, flooding affects 106 million people yearly, and salinity affects around 900 million hectares of soil. In addition, according to FAO data, weeds cost the global economy an incredible 95 billion dollars each year. More than half of it goes to developing countries, resulting in 380 million tonnes of wheat being wasted. Plant breeders have worked to improve herbicide tolerance, drought, flooding, and salinity tolerance are just a few of the biotic stress factors. Breeders have attempted to select varieties that are better able to take up the necessary nutrients in the case of poor soils.

The amount of rain that falls in some areas is expected to decline due to climate change, while the opposite is possible in other areas. As a result of these challenges, plant breeders will continue their research and development of new genetic variations to meet these needs.

E. Quality of the Crop

Here are a few examples of crop adaptations by plant breeders. The development of monogerm sugar beet varieties has reduced the need for labour-intensive thinning and enabled fully mechanized cultivation; the malting quality of barley has been improved, with production rising from 2,000 litres of beer per tonne in 1950 to 8,000 litres per tonne in 2008. Brussels sprout hybrids have been developed with uniform ripening and size to make them suitable for machine harvesting. Vegetables now have a better flavour and more health benefits than ever before.

2.4 Opportunities and challenges of plant breeding toward climate change

A few examples of the current contributions of plant breeding that can be considered opportunities are found below.

They highlight the benefits of combined public and private efforts toward producing varieties with more desirable traits that will benefit mankind.

a. New Rice for Africa (NERICA)

In many parts of West Africa, rice is a major food and energy source, and the United States imports about $1 billion worth of rice each year. African rice (Oryza glaberrima) has been cultivated for over 3,500 years and is well adapted to the African environment. The rice gall midge, rice yellow mottle virus, blast disease, and drought are all resistant to it. To keep weeds at bay, it has a lot of vegetative growth. However, this type of rice is susceptible to lodging and produces low yields. An additional issue is that the grains may shatter, which reduces the yield even further. This led to the abandonment of

African rice cultivation in favour of Asian varieties (O. Sativa) with higher yields, which were introduced to Africa around 500 years ago. As a result, they are not well-suited to African conditions due to their short stature, which makes them easy prey for weeds and other African pests and diseases.

The African Rice Center (WARDA) worked with plant breeders to create new rice varieties by crossing these two types to try to solve these issues. It was necessary to use embryo rescue techniques, as they normally don't mate. Varieties of both upland and lowland plants were bred that showed heterosis and outperformed their best-performing parents. As a result, the yields of these Nerica lines could rise from about 1 to 2.5 tonnes per acre of land. Fertilizer increased yields to 5 metric tonnes per hectare. Because they are more pest-resistant and taller than the majority of other varieties and therefore require less water for cultivation, the new lines have a protein content that is 2% higher than that of the current varieties and could therefore be adapted to drought conditions (Nerica, 2009).

b. Tropical Sugar Beet

As water shortages are becoming more prevalent around the world, sugar beet can be grown in relatively dry areas because the crop requires less water than sugarcane. Plant breeders have aimed to develop tropical sugar beet varieties that produce the same amount per acre of sugar as sugar cane, but use only one third to one half of the water. This could save up to 10,000 cubic metres of water per hectare. In addition, these new varieties grow faster, allowing farmers to grow a second crop in the time it would take sugar cane to mature. About 10 tonnes of white sugar could be produced in five to six months instead of a year in a single hectare.

Cane or other crops would not thrive on saline or alkaline soils where this tropical sugar beet could thrive. Last but not least, research shows that the plant removes the same amount of carbon from the atmosphere in half the time sugar cane does (Syngenta, 2007).

c. Water Efficient Maize for Africa (WEMA)

Many small-scale farmers rely on rainfall to irrigate their crops, making maize farming risky for millions of people. Researchers have identified drought tolerance as one of the most important aspects of crop improvement. Conventional breeding, marker-assisted breeding, and biotechnology are being used to develop drought-resistant maize in the WEMA project. Other efforts like identifying ways to mitigate drought risk, stabilizing yields and encouraging small-scale farmers to adopt best management practises will be crucial for realising food security and improving these farmers' lives (AATF, 2009).

d. Africa Biofortified Sorghum (ABS)

Sorghum has high fibre content and a low rate of nutrient digestibility, both of which contribute to its low consumer acceptance. They have caused a decline in production due to unpredictable rainfall, declining soil fertility, inefficient production systems, and biotic and abiotic stress. The ABS project aims to develop more nutritious and easily digestible sorghum with increased vitamin A, iron, zinc, and essential amino acids, such as lysine, through plant breeding and related technologies. The project's success could benefit 300 million people's health (Biosorghum, 2009).

CONCLUSION

Crop improvement through breeding provides enormous value compared to investment and is an effective approach to improving food security and agriculture. Through the development of new seed varieties with improved genetics derived from germplasm exhibiting stress tolerance, plant breeding has attempted to assist farmers in meeting the enormous challenges posed by climate change. Improved crop varieties and hybrids bred in this field can reduce greenhouse gas emissions by increasing nitrogen and CO_2 input-use efficiency and being more productive, high-quality, and resistant to biotic and abiotic stresses. For the conservation of biodiversity and deforestation reduction, they also developed high-yielding crop varieties, which saved a million hectares of land Despite these obstacles, plant breeding is essential if we are to increase the amount of high-quality food we can produce in the face of rising global temperatures, an increasing human population, a lack of urgently needed government measures, limited application of new methods, a lack of resources, inadequate education and training, and an increase in the number of insects and diseases.

Future Perspectives

For plant breeding to thrive, it must be supported by policies encouraging innovation and investment. A new generation of plant breeders must be educated in order to halt and reverse the worrying trend of decreasing crop improvement capabilities. Plant breeding in the twenty-first century will not be successful without successful partnerships, including synergies between the public and private sectors. Improved chain cohesion through the use of a continuum approach to managing food and agriculture's plant genetic resource base. It's also critical that developing countries' National Agricultural Research and Extension System be restructured, strengthened, and overhauled because crop improvement and other interventions require a long-term foundation. To help countries develop result-oriented breeding programmes, the development of a set of actionable policy interventions to be packaged is also necessary. In addition, some of the strategic policy, scientific, technological, and partnership interventions of plant breeding that can help national programmes, especially those in developing countries, to have responsive and result-oriented crop improvement activities are highlighted in this section.

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