Role of Plant Biotechnology in the Advancement of Classical Agriculture

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ABSTRACT: This review paper contains some of the places of interest of modern plant biotechnology and discusses the possible uses of biotechnology in the betterment of agricultural systems. Plant biotechnology will make easy the farming of crops with numerous strong resistances to pathogens and diseases, mainly in the dearth of pesticides. Similarly, transgenes or marker-assisted assortment may help out in the expansion of high yielding crops, which will be desired to give food to the world and keep land for the preservation of plant biodiversity in natural habitats. That's why, crops be supposed to be engineered to meet the demands and needs of clients. Genetic makeup of crop production can be conserved and extend by the addition of biotechnology tools in conservative breeding. Likewise pointing specific genotypes to specific cropping systems can be facilitating by understanding the particular gene by surroundings exchanges with the help of molecular research. Elevated quality crops that are with better nutritional value and health uniqueness other feature of inserted value may also be obtain from end to end multidisciplinary assistance between biotechnologists, plant breeders and the other plant scientists. Organize labors between policy makers, farmers, clients and researchers will be necessary to exchange a variety of aspect of a crop ideotype into the apparatus of new and advanced agricultural systems.

Keywords: Plant Genomics, Gene Banks, Dna Banking and Virtual Plant Breeding, Ceuticals.

INTRODUCTION

At the last of a year, decade, century, for all time offer a chance to imitate on the human doings in a specific categorize put together a future approach. Researchers frequently observe history happening in order to find out instruction that can help in the acquirement of the new knowledge or for the advance of suitable technology subsequent for it. Obviously, science and the technology are not remote in the world; so that researchers are estimated to proceed according to the shifting inclusive society in which they are exist. This activities might be seen as the foremost dare of crop biotechnology, i.e., to mull over the communal performers in the research schedule and effort. In the other terms, advertise forces, client demands, and communal analysis cannot be unnoticed when concentrate on the essential and intentional research issues because these causes specific scientific researches and technology or invention expansion.

BACKGROUND INFORMATION

Reviewing role of plant biotechnology in advancement of agricultural systems do not seems to be an effortless job due to the quick advancement in this field. In the last century the world has observes the climbing of the genetics as a scientific regulation (1900s), the judgment of the DNA as heritable substance (1944), the exposition of the double helix structure of the DNA molecule (1953), the spliting of the genetic code (1966), the capability to segregate genes (1973), and the function of DNA recombinant techniques (1980).

Techniques of crop development have also altered significantly all through this century. Gathering and wild type selection in landraces, containing of genotype mixtures, were the admired breeding techniques pending the 1930s for most crops. In the 1930s maize breeders on track the commercial development of double cross hybrids that was go after by the widespread process of single crop hybrids since the 1960s (Troyer 1996). Pedigree, bulk,

backcross and the other collection methods were developed particularly in self-pollinating crop species. This scientific advancement in the plant breeding led to the 'Green Revolution', the supreme success to give food to the world in the years of the Cold War (Perkins 1997). Due to this agricultural betterment, cereal production, which financial records for upto 50% of the whole energy uptake of the world's deprived, set aside in pace with the high common population growth rate of 1.8% given that 1950 (Daily et al. 1998). Today, 370 kg of the cereals per head are collect as contrast to only 275 kg in the 1950s; i.e., in surplus of 33% per capita gain.

Comparable development in other food crops consequence in 20% per capita gains since the early on 1960s, an estimate of FAO (1995). There are 150 million or smaller quantity are hungry humanity in the world, 40 years ago, though there are double as many human beings. Regardless of this marvelous advancement in crop yield, even greater progress should be ready in order to nourish an further two billion people by the early part of the 21st century (Anderson 1996a). Around about 800 million people are famished today and another 185 million kindergarten children are still scrawny due to deficient in food and water, or disease (Herdt 1998).

Therefore as recommended by the Nobel Peace Laureate, Norman Bourlag (1997), new biotechniques, in accumulation with predictable plant breeding, are needed to improve yields of the crops that nourish the world. vigilant choice of such biotechniques as well as a sensible evaluation of their potential in crop improvement are needed to avoid not only the disapproval of the anti-science lobbyists but the enduring disbelieve of practical traditional breeders (Simmonds 1997). For example, a World Bank board lately unconfined for conversation a well based report relating to bioengineering of crops (Kendall et al. 1997) agricultural output in the rising world while heartening the essential change to sustainable techniques". Undeniably, plant biotechnology has been considered as precedence areas for technology transfer (Altman and Watanabe 1995), since GM food, nourish, and fibers are of fundamental anxiety to the developing world (Ives and Bedford 1998). For that reason, the wealthy developed world should divide their biotechniques and keep away from policies that not permit the development of agriculture in poor, no industrialize parts of the world (Erbisch and Maredia 1998), where this profitable bustle at rest supply 60 to 80% service and 50% of national profits (Anderson 1996a).This type of sustain will aid the rising world for food self-reliance (Herdt 1998),that will be significant to keep away from hunger and will keep calm in many areas of the tropics, somewhere the agricultural region relics the most significant source for economic expansion. Besides, a Well-off society supply high livelihood to its nation. Tissue culture was developed in the 1950s and get popularity in the 1960s. Nowadays, micropropagation and the in vitro management are typical practices in most important food crops particularly that are with vegetative propagation. On the starting of the 1980s genetic engineering of plants, even though first gene transfer was achieved in agrobacterium. Tobacco was the first transgenic plant. Transgenic crops with insect resistance herbicide resistance, insect or virus resistance, postponed fruit ripening, male infertility, with chemical composition have been unconfined to market during this decade (NCGR 1998; USDAAPHIS 1997). There were about 3 million ha of transgenic crops grow in the world (chiefly in North America) In 1996, while in the surplus of the 34 million ha of transgenic crops collected this year in North America, China, Argentina, and South Africa between other countries. In Argentina transgenic herbicide resistant soybean is the leading developing with an surfeit of 4 million ha. Only in North America there are 4.4 million ha of transgenic 5 million ha of transgenic soybean (20%), corn (14% of total acreage), and 1.6 million ha of transgenic canola (42%) are grown (Moore 1998). It was calculated in 1998, the US farmers are rising over 50% of transgenic cotton seeds, one of the greatest percentage for any transgenic crop ever. In the schedule of genetic engineering trees are the next target. The first biochemical genetic markers were Allozymes were available as in the 1960s.

For the early research Population geneticists took advantage of marker system. Restriction

fragment length polymorphisms (RFLP) and Southern blotting were the tool box of the geneticists in the 1970s. In the 1980s *Taq* polymerase was originated and the polymerase chain reactions (PCR) were introduced. a technique known as 'gene chips 'is that the marker-aided analysis based on PCR have develop into practice in plant genetic research and marker systems have exposed in plant breeding (Paterson 1996). Moreover, new solitary nucleotide polymorphic markers foundational on elevated concentration DNA arrays, (Chee et al. 1996), have freshly been formed. With 'gene chips', DNA belonging to thousands of genes can also be arranged in tiny chips and probed with labeled cDNA from a tissue of interest. DNA chip tools uses microscopic arrays of molecules ineffectual on solid surfaces for biochemical analysis (Lemieux et al. 1998; Marshall and Hodgson 1998; Ramsay 1998). We may read this information with an electronic device connected to a computer, which facilitates marker-assisted choice in crop breeding. In summary there have been five eras in genetic marker evolution (Liu 1997): morphology and cytology since Mendel's work on peas, electrophoresis in the pre-recombinant DNA time (1960 -mid1970s), RFLP and mini satellites in the **pre-PCR age** (mid 1970s - 1985), accidental augmented polymorphic DNA, microsatellites, uttered succession tags, succession tagged sites, and the enlarged splinter length polymorphism in the Oligocene period (1986 - 1995), and absolute DNA progression with known or unknown role as well as absolute protein catalogs in the recent computer robotic cyber genetics generation (1996 onwards) The dynamic strength for such an advance has been the systematic attention of the human beings to appreciate and influence the bequest of their individual characters.

FEEDBACK TO BIOTECHNOLOGY IN FOOD CROP ADVANCEMENT

The improvement in the plant genomics and transgenic explained beyond has not been isolated from civilization (Busch et al. 1991).some achievements of plant biotech have been highly praised by consumers while other are accomplishments, e.g. advent of genetically modified organisms (GMO), are being criticized, by political campaigners. A number of these educated middle-class activists are articulate in a way their unbridled 'eco-paranoia', some of them hides their genuine plan to influence the chic ecological movement. These controversies have fascinated the notice of non-scientific partizans of both sides. There are many unenthusiastic remarks about the transgenic plants by a crown prince and complementary positive remarks by a former president, both of them may not have the necessary scientific information to tax the potential of biotechnology for crop advancement.

This ideological quarrel and resulting self-ruled incongruity; biotechnology yield will be accepted by people who support scientific-based progress, in a similar way that new cultivars or pioneering crop husbandry techniques have up to that time become fundamental parts of farming systems in a different places. On the other hand, without formers approval, the collision of a new technology in the culture will be minute or nil. To convince people about the advantages of biotechnology for crop improvement the scientific honesty seems to the best policy (Frewer et al. 1998).The Scientists, Farmers, consumers, and policy-makers are supposed to impartially review the potential dangers of crop biotechnology in agriculture and farming systems concerning the existing circumstances and the probability this type of risks may take place. Scientists must be explaining to the people that gene recombination or reassortment already take place in nature. On the other hand, the ecological victory of feasible recombinants after gene recombination is erratic due to the elevated fitness of recent isolates. Due to that reason, more scientific research will be needed to recognize erratic hazards and the probability of their occurrence.

the private sector to defend their savings in crop biotechnology due to the need for profit, as in any other business, has paying attention the attention with patents, logical property rights, and new shield techniques, e.g. 'terminator' technology that reduce germination of self-pollinated seeds. This expertise fortification scheme prevents farmers from saving seeds

from their harvest for further consumption as next season growing propagates.

Three genes, with a definite promoter, are incorporating into the genome of 'terminator' plant (D.E. Culley, Washington State Univ. in RAFI 1998). One of the genes (e.g. CRE/LOX system from bacteriophages) construct a recombines that eradicate a spacer between the gene producing,. This spacer with definite identification sites blocks the gene of the ribosomal suppresser protein from being triggered. One more gene i.e. tetracycline repressor system produces a repressor that keeps switch off the recombinase gene until an external motivation is practiced to the 'terminator' plant, e.g. tetracycline, or temperature and osmotic alarms. The USDA (United States Department of Agriculture) and a cotton seed project mutually attained a patent for this conception (U.S. patent 5,723,765). Two months after this official document was announced, the agro-chemical transnational's bought the cotton seed company, it may take many years before this even if one of its officers said that 'terminator gene' idea becomes a verified equipment in the seed industry. Some foremost scientists are departure their academic arrangements to join the new private ventures in plant biotechnology. These proceedings are occurrence because the private sector wants to use biotechnology to speed up its growth in agri-business in the short-term. However, finances to grasp up fundamental and tactical research by public researchers are required for an enduring sustainable relocate of public to the private sector or other end-users

BIOINFORMATICS

An additional essential feature in the advancement of the genetic development of crops was the advance of rapid and more dependable computers, which permitted easier supervision and analysis of data as well as publication of scientific reports. The collision of the informatics rebellion in crop development can be moderately assessed by counting the quantity of publications indexed in Plant Breeding Abstracts (CAB International, Wallingford, Oxon, UK). There was ca. 22-fold increase of publications in the 1930-1997 ages indexed publications in plant breeding surpass 10,000 per year it was in the 1970s. new publications and simple means for repossessing this information accounted for this type of expansion of knowledge broadcasting in plant genetics and breeding.

Nowadays, quick information swap has been smooth the progress of with electronic mail and access to the internet to read electronic publications. Currently, information technology and DNA science are beginning to fuse into a single operation.

Computers are interpreting, and categorize the huge genetic information that can become "the ssraw store of the emerging biotech economy" in the next century (Rifkin 1998). Scientists functioning in the new discipline of "bioinformatics" are mounting biological data pools to download the genetic information build up during millions of years of the life evolution, and conceivably renovate some of the living organisms of our ordinary world.

PLANT GENOMICS

It can be defined by the advancement of biotechnology; leads to the exploration of total genomes by assimilate genetics with the bioinformatics and the programmed methods. Genomic research intends to illuminate the evolution, structure and function of present and past genomes (Liu 1997). Dynamic fields that concerning with agriculture are the sequencing of plant genomes, proportional mapping crosswise species with the genetic markers, and also with objective supported breeding later than identifying aspirant genes or chromosome sections for additional manipulations. The conclusion of genomics, the idea of gene pools has been distended to embrace transgenes and native foreign gene pools that are accessible throughout proportional analysis of plant biological repertoires (Lee 1998).**B**iological character of one species may suppress the capability to attain high yield or improved manufactured goods worth in another organism.

Gene sequencing and DNA markers offers quantitative resources to decide the extent of genetic diversity and to set up goal phylogenetic relationships among organisms. 'Gene chips' and

transposon labeling will supply new scope for look into gene expression.

The molecular biologists not only study individual genes but they also study circuits of interacting genes in different pathways manage the continuum of genetic variety in any crop species more information will also be accessible on why plant resistance genes are clustered together, or what applicant genes should be consider when manipulating quantitative trait loci (QTL) for crop advancement.

ENVIRONMENTAL FRIENDLY AGRICULTURAL SYSTEMS

The aims behind the practical plant science research for agriculture are to improve crop yields, developed food rank, and defend the habitat of human and other organisms. Protection of plant biodiversity and its environment can be achieving elevated crop yield per ha. Briggs in 1998 information that as capitulate treble, wearing a way of soil per ton of food reduce by two-thirds. A important yield improvement due to superior crop husbandry, by changing plants but in the next years progress will be achieved that will be appropriate to sustainable and environmentally friendly agricultural systems. pest and disease resistance in transgenic crops will achieved by Agro-chemical corporations and also helps to avoid pollution with pesticides in the agriculture. Moreover, the quality of food has more importance than crop productivity in developed countries. Transgenic crops with desired characteristics will be preferred by consumers Briggs (1998), “transgenes must be analysis as upgrading rather than replacements for selected germplasm”. In reality, genetic engineering may supply a means to add value by initiateing synthetic or natural genes that improve crop quality and quantity, as well as defend the plant against pathogens and diseases. Farmers will pay more for transgenic crop propagules in the way they get additional profits after adopting biotech-derived products i.e. seeds of insect resistant transgenic crops will be pricier than those of accessible cultivars but the farmer will not need to sspry pesticides in their transgenic fields., patents make transgenic seeds more expensive but also farmer’s profit may also be privileged.

GENE BANKS, DNA BANKING AND VIRTUAL PLANT BREEDING

In plant biodiversity and its genetic enhancement the sequencing of crop genomes opened new frontiers in conservation. The proceedings in the gene isolation and sequencing in many plant species permit to predict that within a few years, gene-bank curators will replace the large cold stores of seeds in future while crop DNA sequences that will be electronically stored. The descriptions of plant genomes will eventually build a true gene bank that will possess a large and nearby gene record of today’s non-characterized crop gene pools. Itinerary, seed banks of lengthily explore stocks should remain because geneticists and plant breeders, the main users of gene banks, will need this germplasm for their work. Genomics may speed up the consumption of entrant genes vacant at these gene banks during transformation without barricade across plant species or other alive kingdoms. On the other hand, genetic engineering should be seen as one of the techniques of plant breeding that authorize the straight modification and re-building of a crop population. “Shutting-off” genes coding for undesired distinctiveness may be another relevance of transgenics in crop improvement. Plant breeders will change their modus operandi with the advance of intention marker-assisted introgression and selection methods. Backcross breeding will be edited by abolishing undesired chromosome segments (also known as linkage drags) of the donor parent or selecting for more chromosome sections of the recurrent parent. Parents of elite crosses may be chosen based on a amalgamation of DNA markers and phenotypic estimation in a selection index, such as best linear unbiased predictors (Bernardo 1998). To achieve success in these endeavours, cheap, easy, decentralized, and rapid analytical marker dealings are requisite.

Many areas of basic and deliberate research in plant breeding and genetics that are being assist by marker-aided analysis (Paterson 1996). With molecular markers, plant biologists are

reviewing crop evolution and gathering new knowledge. This type of information should be

Integrated into genetic augmentation programmers, particularly evolutionary breeding scheme. Similarly, plant ideotypes for every crop coerce the work of plant breeders. Precise plant morphotypes are distinct in rice and wheat based on gathered knowledge of crop physiology and crop protection.

Essential features are compulsory to develop better plant prototypes consequential from such a 'virtual breeding' advance may be accessible in gene banks of the crop or other species. if not, breeders may find novel transgenes to extend the essential ideotype.

Currently, the discovery of new genes that can add worth to agricultural products appeases to be very imperative in the private agri-business. Distinctive gene catalog are being accumulate by the industry with the enormous quantity of data engender by genomics research. 'Biosource' a new term that was coined freshly to submit to a rapid and effectual licensed technology of pinpointing genes. With the help of this method, a 'benign' virus infects a plant with a detailed gene that permits researchers to observe openly its phenotype. Biosource restores the standard prolonged advance of first mapping a gene to consequently establish its accurate role. Identification of the gene in DNA libraries tied with biosource technology and an improved aptitude to put genes into plants will be practice for improving crops. Genomics may supply a means for the exposition of imperative purpose that are necessary for crop adaptedness (Wallace and Yan 1998). Areas of the world should be mapped by coalesce data of geographical information systems, crop presentation, and genome classification in each environment. In this way, plant breeders can expand new cultivars with the suitable genes that develop fitness of the talented assortment. Fine-tuning plant comeback to separate environments may augment crop efficiency. Improvement of cultivars with an extensive variety of version will allow farming in unimportant lands. As well, research proceeds in gene guideline, particularly those processes regarding plant development prototype, will help breeders to fit genotypes in definite environments. Photoperiod inconsiderateness, flowering opening, verbalization, cold acclimation, heat tolerance, host response to parasites and predators, are some of the individuality in which advanced knowledge may be obtained by coalesce molecular biology, plant physiology and anatomy, crop protection, and genomics. Multidisciplinary co-operation among researchers will supply the required holistic advance to facilitate research progress in these subjects.

AGRICULTURE AND FARMER-CEUTICALS

Enlargement of cities in the urbanized world has previously reinstate farmland with shopping malls, parking lots, and housing developments. Peri-urban agriculture anssd home gardening are also becomes very important for national food security in the developing world as a result of rapid urban development. Therefore, new cultivars will be desired to fit into exhaustive construction systems, which may supply the food compulsory to gratify urban world demands of the next century. Definite plant construction, tolerance to urban pollution, proficient nutrient uptake, and crop getting used to new substrates for growing are, among others, the plant sindividuality required for this kind of agriculture. Genes scheming these characteristics may be obtainable in gene banks for further cross breeding, which can be ad by genomics. Peri-urban and home garden "farmers" will have to adapt to new demands from emerging urban populations

With higher income. These clients may demand a more diverse diet. Food crops with low fats and high in specific amino acids may be needed to satisfy people who wish to change their eating habits. If genes controlling this uniqueness do not exist in a specific crop pool they may be incorporated into the breeding pool using transgenics. Some publications probable that in the next millennium food will not need to be harvested from farmers' fields (Anderson 1996b). Tissue culture of specific piece of the plant might meet the expense of a means to attain success in these attempts. Suitable for eating portions of fruit crops might be grown-up in vitro. A stable and contemptible provider of

these ripe plant parts will be essential in this new agri-business.

That time consuming process can be scaled up for commercial purpose. On the other hand, an official document was proposed in 1991 by a Californian biotech corporation for manufacturing a vanilla extract in the course of cell culture. Literary, this method will not reinstate agricultural as we be familiar with it today.

This biotechnique, and other new agricultural methods, proffer means for new methods of producing foodstuff, nosh or fiber. Frequently plants supply the unprocessed resources for agro-industry, and not only for food or fiber dispensation but also the fuel and pharmaceuticals. vigorous constituents of plants have been altered into profitable goods such as drugs, solvents, dyes, and non-cooking oils for several years. Thus, it would not be astonishing to observe, in only some years from at the present, intact ranch without food crops but mounting transgenic plants to fabricate new yield, e.g. suitable for eating plastic from peas or plant oils to fabricate hydraulic fluids and nylon (Grace 1997). This new bucolic doings may consequence in imperative transform in the national economic sector. 'Pharming' has been further to the lexicon to signify a new kind of system to obtain medicines (Anderson 1996b).

For example, oral vaccines materialize to be a suitable liberation system for vaccination all through the world. Biotechnology can persuade plants that have a gene derivative from a human pathogen (Tacker et al. 1998). An antigenic protein programmed by this distant DNA can amass in the ensuing plant tissues. Fallout from the preclinical examination demonstrates that antigenic proteins yielded from the transgenic plants were capable to maintain the immunogenic possessions if disinfect. The antigenic proteins basis the construction of definite antibodies in introduced mice. Mice, those who eat these transgenic plant tissues, also demonstrate a mucosal immune response. Arakawa et al. (1998) freshly established the capacity of transgenic food crops to persuade shielding immunity in mice alongside a bacterial enterotoxin as in cholera toxin B component hexamer with resemblance for the GMI-ganglioside. In addition, potato tubers are being used lucratively as a biofactory for the standard outcome of the recombinant single chain antibody (Artsaenko et al. 1998).

HAZARDS EVALUATION OF TRANSGENIC AGRICULTURE

Deficiencies of scientific information, non-scientific partizan observations, improbability of the latent hazards, plus unawareness confound rational argument relating to the liberate of GMO. Issue of discharge genetically modified plants (GMP) into the agricultural system has turn out to be chiefly disturbed by supplicant collection in Europe regardless of pervasive agriculture of such crops in North America and in another place. Sentists should appreciate that the common public are anxious that an incautious advance to the exploitation and agriculture of transgenic crops may influence biodiversity, sustainable consumption in the agriculture system, e.g. thrashing of unpredictability and feasibility.

Populace also desires that their spectacle about demand of biotechnology for humanizing agriculture is pay attention irrespective of their information in the topic. Furthermore, farmers are scared those unenthusiastic misinformations jeopardize the public icon of their harvest. Scientists and strategy makers must not recall that people's satisfactoriness is the most important element of the general public evaluation of risk, which comprise both ambiguity and negative penalty. This suitability depends on artistic factor since people's outlook modifications according to occasion and position. The procedure of hazard evaluation in agro-chemical consists of hazard recognition, disclosure evaluation, effect's administration, threat categorization, and hazard management. Although, transgenic crops may be capable to occupy, and multiply in various environments. So that, this hazard evaluation of a genetically modified alive organism mull over other character not incorporated when evaluated the release of dead compounds to the surroundings. What are the potential ecological risks associated with the release of GMP into the farming system? These are itinerary a very huge

number of potential hazards, perhaps the two mainly significant hazards are GMP ascertain in semi- or natural environments and incorporated transgenes include into other species thus upsetting non-target organisms in fields or natural habitats.

End user concern about transgenic crops also spotlight on their protection as food, chiefly if alterations may perhaps manipulate their metabolism or health. In this regard, transgenic plants without selectable markers, such as antibiotic resistance genes, are required to influence GMP sceptics of the advantages of genetic engineering for crop improvement. In this way, their criticism concerning the potential hazard of transgenic crops could be overcome.

CONCLUSION

In the next 7 or 14 years, five research areas may become very important for development of agriculture: apomixes to fix hybrid liveliness, male infertility systems with transgenics for hybrid seed in self-pollinating crops, parthenocarpy for seedless vegetables and fruit trees, for quick development of jungle and fruit trees, and converting annual into perennial crops for sustainable agricultural systems. The enlargement of perennial crops is especially important to defend the soil from wearing away. Plant biotechnology will participate, itinerary, and significant function in accomplished research and the development in these regions.

Exclusion of transgenic crops from the agricultural system will be stupid as the possible benefits of transgenic crops are so huge. Environmentalists must review or recall 'Silent Spring' by Rachel Carlson (1962). What on earth scientists do to expand crops that eradicate or decrease the consumption of polluting agro-chemicals in the agricultural systems should be reception by farmers and consumers. For example, a fascinating loom for developing resistant transgenic crops may be during the development of the plant's defense system.

Inducible and tissue particular promoters might support in this attempt. Accumulative support might direct to new corporations, collaboration or joint ventures in research and improvement among scientists, community and private sectors will beneficial for farmers and consumers with earnings and elevated quality harvests, correspondingly. Any probable hazard in human development related with biotechnology applications in agriculture will be effortlessly resolute in a self-governing society. The public necessitate deciding among safely self-regulated or to follow safety regulations as approved by policymakers after eavesdropping to the views of scientists, manufacturers, and end-users. The common public must see biotechnology as a safe and sound contrivance for scientific crop development, for the reason that it helps in the fight adjacent to hunger and poverty. Hence, research funding must be owed consequently to long-term plant breeding programmers, including biotechnology's tools. We may successfully face the somber dispute of nourishing the quickly growing world's populace.

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