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Sustainable agriculture and biotechnology

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Feeding an ever-growing population is now the major challenge especially when global warming and climate change are knocking at the door. Biotechnology is set to revolutionize the field of plant breeding and can help to secure the food supply. Conventional plant breeding techniques have reached their limit of feeding the global population, with few advances like marker-assisted selection and genomic-based selection is pushing the limit further.For many years we domesticated plants and animals by using traditional breeding methods all we did is just select the desirable traits and breed those who have them. These traits were height, yield disease resistance, appearance, hardiness, tolerance to adverse climatic conditions. In traditional breeding methods, farmer relies on a chance recombination events to bring together beneficial genes, when particular crosses were performed. The results were unpredictable at the genetic level, DNA from the parent combines randomly as result the desirable traits get bundled up with undesirable traits and lead to poor yields and poor quality. By introducing the genes directly into the genome genetic engineering cut short the process. It removes the limitation of sexual compatibility when carrying out crosses since genes from any source like bacteria, plant or animal can be transferred into the recipient organism. Given that G.E crops or GMOs grow in a total of 67 of 195 countries. It is the fastest adopted crop technology. The recent stat. depicts that acreage of gm crops worldwide from 2003 to 2019 came to some 190.4 million hectares.

Biotic resistance

- **Viruses' resistance**

Major losses occur every year as a result of viral infections Examples of tobacco mosaic virus TMV causes losses of over $50 million per year in the tomato industry. Another example of cassava brown streak virus CBST that causes economic losses up to $100 million per year. There is a useful phenomenon known as cross-protection in which one strain of virus protects against superinfection with a second. So, in the case of TMV Power, a hell 1986 developed transgenic plants which express DMV code protein and greatly reduced disease symptoms following virus infection. In case of resistance to TMV, the code protein must be expressed in vascular tissue through which the virus spreads systematically. Transgenic squash containing multiple viral coat proteins genes and demonstrating resistance to Cucumber to Jaguars watermelon mosaic virus.

While the heterologous coat approach can be useful it has been demonstrated that in many cases the effect of transgene expression to interfere at RNA rather than at protein level is effective. This is first shown in Lindbo and dougherty in 1992. Using tobacco etch virus court protein gene. The transgenic plants carry coat protein genes that cannot be translated to yield functional protein. The translation RNA interferes with viral replication of phenomena usually called RNA mediated viral resistance or RNA interference. This process is similar to post transcriptional gene silencing.

A similar approach is used in the case of cassava in Africa cassava brown streak virus is considered a threat to food security. cassava plants for modified to produce interfering RNA from shortened from the full length at N-terminal portions of CBSV coat protein portions. RT PCR diagnostics indicated the presence of cassava brown streak virus in non-transgenic plants but few transgenic lines were pathogen-free. At the harvest, 90% of the storage roots of non-transgenic plants were severely infected by cassava brown streak virus-induced necrosis. however, few transgenic lines show significant suppression of disease with 95% of roots free from disease and RT PCR test negative.

- **Fungal resistance**

The use of antifungal protein or metabolite is to manipulate the hypersensitive response which is Physiology but a defense mechanism used by plants to defend themselves from pathogens. The response to an avirulence gene (avr) In pathogen. when pathogen signal metabolite is released into the plant system, Plot launches a range of self-defense responses including cell death or forming a barrier at a site of the attack and detaching the part that is affected, so that it doesn't spread Further. in 2001 his strategy was developed in which they transferred avirulence gene (avr9) gene from pathogen to tomato under the control of pathogen induced promoter. The transformed plant showed resistance against fungal pathogens.

Another diseased name late blight- caused by *Phytophthora infestans* infection is a major constraint for potato farmers costing them an estimated USD 3-10 billion per year globally.

In Uganda where about 300,000 smallholder farmers grew potatoes, the disease can destroy as much as 60-100% have of the crop. due to diseases such as late blight potato yield are four time lower on average in developing countries compared to yielding industrialized nations. farmers use fungicides to control late blight but the coast of these agrochemical can represent 10 to 25% of the total value of farmer potato harvest. Over the year breeders have crossed potato with wild relatives to produce late blight resistant variety but the resulting varieties lack those traits people wanted. Search through genetic engineering three broad-spectrum resistance genes isolated from wild potato relatives were transferred into four susceptible farmer preferred varieties 'Desiree' and 'Victoria' and these genes were *RB and Rpi-blb2* from *Solanum bulbocastanum and Rpi-vni1.1* from *Solanum venturii.* In the field resistance transgenic events from potato varieties 'Desiree 'and one from 'Victoria' grew normally without showing pathogen damage and without any fungicide spray whereas non-transgenic equivalent varieties were rapidly killed. The yield of two transgenic events from Desiree and Victoria grown without fungicide to reflect small-scale farm holders were estimated to be 29 t/hectare and 45 t/hectare respectively. This represents a three-to-four-fold increase over the national average, thus these late blight resistant potato varieties which are the farmer preferred varieties could be rapidly adopted and bring significant income to the smallholder farmers in sub-Saharan Africa.

- **Bacterial resistance**

Banana Xanthomonas wilt (BXW) is a bacterial disease that spreads easily and kills any banana plant it infects — farmers' only recourse once an infection takes hold is to cut down and burn the entire plant. Every species of cultivated banana is susceptible to BXW. Bananas are notoriously susceptible to disease because they are all clones. In the past, varieties of banana have been driven virtually extinct by infections like Panama Disease, and today, viruses, bacteria, and fungi again threaten the world's banana supply. And in places where the fruit is a primary source of both income and food, such as Africa, an infection can threaten not only farmers' livelihoods but the entire local economy. The disease-resistant banana plants looked just like unmodified ones and grew just as readily. However, several showed no symptoms of BXW after exposure to the bacteria behind it. The concept is that knocking down MusaDMR6 using CRISPR (Clustered regularly interspaced short palindromic repeats) in banana showed enhanced resistance to a critical disease, BXW, and did not show any detrimental effect on plant growth

- **Insect resistance**

Insect pests represent one of the most serious abiotic pressure to crop production. for example, more than one quarter of all rice grown in the world is mostly lost to insect-pest, estimated cost of nearly $50 billion. this is despite an annual expenditure of approximately $1.5 billion on insecticide for this crop alone. Insect pest-resistant plants are therefore desirable not only because of potential increase yield but also because of the help of these insect-resistant crops we could avoid the accumulation of harmful chemicals in the environment. Typical insecticide is nonselective so they kill harmless and beneficial insects as well as pest. for this reason, transgenic plants have been expressing toxins that are selective for particular insect species.

All commercially approved insect-resistant crops produce a toxin that comes from a gram-positive bacterium called bacillus thuringiensis. This bacterium produces crystal during sporulation comprising of a small number of protoxin crystal protein. These proteins are highly specific insecticides. the specificity of this protein reflects the interactions between crystal proteins and the insect gut. when this is ingested by insects, ingested crystals dissolve in alkaline conditions of the gut and protoxin are activated by gut proteases. The active toxin binds to the receptor on mid-gut epithelial cell, become inserted into plasma membrane and form spores that can lead to cell death and eventually the death of insect. This toxin can provide resistance against lepidopteran insects (tobacco dudworm, army worm). These genes were initially introduced into tomato and tobacco and later in cotton resulting in the production of insecticidal proteins that protect the plants from the insect infestation. However, the field test of these plants revealed that higher levels of toxin a plant tissue would be required to obtain commercially useful plants from that on there are many attempts to increase the toxin gene in plants by the use of different promoters but none are successful. The recent example is GM cowpea In Nigeria. The protein rich cowpea commonly known as poor man's meat is a country staple legume. This new variety took a team of African and international devotees 40 years to develop and 20 years to improve its traits through traditional breeding and another 20 years using genetic engineering to develop resistance to resistance against maruca pod borer. While in India BT brinjal was developed in 2008 but still is struggling for approval for commercialization.

Abiotic resistance

- **Drought tolerance**

The unfavorable environment conditions represent the next major challenge in crop production. As the global temperature rises agriculture is severely affected as crops cannot withstand the heat. And the development of transgenic crops with in drought resistance could increase global yields hopeful by 30 to 50%. Many plants respond to drought or prolonged dehydration by synthesizing small very soluble molecules such as betaines, sugars, amino acids and polyamines. These are collectively termed as compatible solutes as0 they increase the osmotic potential within the plant therefore preventing the water loss in short term help in maintaining normal physiological ion balance in long term and they are not even toxin when accumulated in larger concentrations, so one way to make plant drought tolerant is to increase the concentration of these molecules.

Another way of making drought tolerant plants is to find the right genes. sub–Saharan Africa remains the most food-insecure region in the world with an estimated 237 million throughout the region suffering from chronic undernutrition frequent drought are partially to blame for the persistent food shortages at the dry conditions are making farming particularly challenging for the regional smallholder farmers. That TELA project has been working on commercially genetically modified drought tolerant and insect resistant mage varieties for more than a decade and field trials are now beginning to raise hope for finding a long-term solution to region's food insecurity. genetically modified maize hybrid provides insect resistance with the help of bt toxin from bacterium commonly known as *Bacillus thrungensis* and drought tolerance with the help of another bacterium called *Bacillus subtills*.

Biofortified plants

A British researcher Cathie martin developed genetically modified tomatoes. Purple tomatoes have been developed by inserting two genes from snapdragon, a flower, in tomatoes to grow purple tomatoes that have health protecting anthocyanins. The genes were: Delila (Del) and Rosea1 (Ros1) genes produce the transcription factors which combine to produce anthocyanins in snapdragon (antirrhinum) flowers and the MYB12 gene from arabidopsis thaliana is a flavonol-specific activator of flavonoid biosynthesis. Vectors were introduced using the fruit-specific E8 promoter. Anthocyanins accumulated in the tomatoes at levels higher than anything previously reported for metabolic engineering in both the peel and flesh of the fruit. The fruit has an intense purple color. Anthocyanins are naturally occurring pigments found at particularly high levels in berries such as blackberry, cranberry and chokeberry. And the researchers claim that purple tomatoes have been shown anti-inflammatory effects compared to regular ones and also slow the progression of soft-tissue carcinoma in cancer-prone mice. They also have doubled the shelf life of the fruit.

Getting enough vitamin, A is essential for not only children and newborns, but also for pregnant and lactating women. Currently, vitamin A deficiency (VAD) is the primary cause of preventable childhood blindness and an important cause of infant mortality. While VAD is hardly the only major form of world-wide malnutrition, biofortification efforts like golden rice stand to dramatically improve the lives of millions of people around the globe by reducing the impact of VAD. The problem is a simple one to correct, is a micro-nutrient deficiency of vitamin A. It comes from a diet of beta-carotene. That orange thing in carrots. The problem is that most world food staples don't contain beta-carotene, a good example in India wheat, rice and other staple grains contain beta-carotene only in trace amounts which is not sufficient. Thus, it is only through biofortification of grain foods we could increase the nutritive value of grains. Scientists are able to move genes from beta-carotene rich crops to food staples like rice and now is available for countries where vitamin A deficiency is severe. The problem, these technologies existed for more than 20 years and is now approved. After decades in development and approval controversies, the Philippines became the first country on July 21st of this year to formally approve the commercial propagation of golden rice. Another example is the "golden banana, developed by an Australian researcher who inserted a banana gene from Papua New Guinea, and another from bacteria, in the Cavendish banana — the most popular variety worldwide. The technology developed in Australia is transferred to a group of public researchers in Uganda, who are modifying the EAHB and SukaliNdizi varieties, the two most consumed in Africa. Currently, both beta-carotene and iron levels continue to increase.

Acrylamide has been a very serious problem for food manufacturers since it was first discovered in 2002, shown to cause cancer in rodents, and has been considered 'probably

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carcinogenic for humans. It occurs in bread and increases substantially when the bread is toasted, but is also present in other wheat products and many crop-derived foods that are fried, baked, roasted, or toasted, including crisps and other snacks, chips, roast potatoes and coffee. British scientists are growing a new strain of wheat that has been genetically edited to reduce levels of asparagine – an amino acid linked to cancer when bread is toasted. Researchers made these edits using CRISPR in the standard wheat strain to remove asparagine, which is converted to the carcinogenic processing contaminant 'acrylamide'.

New future initiatives in crop genetic engineering

To date, commercial GM crops have delivered benefits in crop production, but there are also a number of products in the pipeline that will make more direct contributions to food quality, environmental benefits, pharmaceutical production, and non-food crops. Examples of these products include: triple stack trait biotech rice with better yield amidst abiotic stresses, the biotech chestnut tree with resistance to chestnut blight, biotech citrus greening resistant citrus, potato enriched with beta carotene, biofortified sorghum, Bunchytop virus resistant banana, carbon fixing eucalyptus trees, insect resistant wheat, among others.

We have solutions to many of world problems but we have yet to deploy their cause of fear and misinformation many of crops that have great potential to do good things exists but they exist in small research plots and not being used in production.

A big problem is of wild weather we've seen examples of flooding, drought and unprecedented heat and cold that have limited the capability of farmers to produce crops worldwide. The inter-governmental panel on climate change released (IPCC) published reports August,2021 that due to our action's environment is degrading rapidly more than we anticipated and we may see extreme weather conditions in our lifetime which we didn't think could be possible. A recent example is Canada, as they are experiencing worst drought in 20 years, a new report is pointing to the record-breaking temperatures as having an incredibly harsh impact on crop output across farms in Canada.

We have genes that can withstand these harsh climatic conditions we can transfer them between crops to make them survive. These plants already exist and they've been tested they work wonderfully but we are yet to deploy them. We have crops like 'TELA' maize which can provide yield up to 3 times of normal, heat stress-tolerant plants that can tolerate higher

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temperatures can provide yields within those higher temperatures, tomatoes that have high levels of (GABA) gamma-aminobutyric acid which helps in lowering blood pressure.

Some people think they are doing a good thing by opposing these technologies are actually slowing its deployment to the people who can use it most and it is not to say that is a universal cure its not we still need to have countless programs that make efforts to genetically improving crops both through conventionally and modern breeding methods. We need to figure out how to grow more food with fewer resources because few people are joining us on the planet soon, the world population is going to be 9.8 billion by the end of 2050 and food insecurity will be the major issue worse than it is now

Genetic engineering is one tool in our toolbox that can solve the problems which we care about and every tool must be on the table if we want to tackle world problems.