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Analysis of Genetic Engineering's Impact on Crop Development in Ethiopia

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Abstract*: Genetic engineering, sometimes called genetic modification, involves manually introducing DNA to an organism. One or more additional characteristics should be added to the creature. Genetically modified organisms are created by genetic engineering. Recombinant technology solves biotic and abiotic stress-related agriculture issues. Due of this potential, the Ethiopian government has invested heavily in contemporary biotechnology capacity development and amended GMO legislation to enable Ethiopian research collaborations on non-edible goods. Ethiopia may become one of the only African nations to sell and produce a genetically altered crop after years of opposition.*

Keywords: Genetic**,** Resistant, Transgenic and Engineering

I. INTRODUCTION

Genetic engineering, sometimes called genetic modification, involves manually introducing DNA to an organism. One or more additional characteristics should be added to the creature. Recombinant DNA is needed to create transgenic organisms. According to, recombinant DNA is a mixture of DNA from various animals or genomic sites that would not usually occur in nature.

Genetically modified organisms are created by genetic engineering. GMO microorganisms and mice debuted in 1973 and 1974, respectively. Insulin-producing microorganisms were marketed in 1982 and GMOs since 1994.Genetic engineering is used in research, agriculture, industrial biotechnology, and medicine. GM cells currently make laundry detergent enzymes, insulin, and human growth hormone, and experimental GM cell lines and animals like mice and zebra fish are utilized for study. Genetically modified crops have been marketed.

Genetic engineers use genetic recombination to change gene sequences in plants, animals, and other creatures to express specified features. Genetic engineering applications are growing as engineers and scientists find gene locations and functions in organisms' DNA sequences. After classifying genes, engineers change them to create beneficial creatures like meat-producing cows, fuel- and plastics-generating microorganisms, and pest-resistant crops. According to Since 1996, genetically modified crops have grown in use and adaptability throughout contemporary agriculture. From 1996 to 2013, genetically altered agricultural acreage increased dramatically. More than 100 times more genetically altered agricultural land was planted between 1996 and 2013. Recombinant technology helps solve biotic and abiotic stress issues. Research has shown that crops may be developed with enhanced nutrient-use efficiency, drought and floods tolerance, disease and insect resistance, and nutritional content and yield. Cotton and maize resistant to lepidopteran larvae and coleopterans are examples of plant genetic engineering's success in agriculture.

Although genetic engineering helps GMO plants and crops survive under many situations, it also benefits humans. It will not replace traditional plant breeding, but it will help plant breeders speed up the process. Transgenic technology created genetically engineered crops with unique genes that provided increased yields, herbicide resistance, insect and disease resistance, drought resistance, salt resistance, and others.

Due of this potential, the Ethiopian government has invested heavily in contemporary biotechnology capacity development in the recent decade. Cotton producers are also interested in pest resistance technology to enhance output. The previous proclamation required the exporting country's competent national authority to take full responsibility for the informed agreement's completeness and accuracy, which prevented local researchers from working with international researchers. However, from May 19, 2015 Parliament Amends GMO Law to Allow Ethiopian Research

Partnerships first on non-edible goods. Director General of the Ethiopian Institute of Agricultural Research Fantahun Mengistu told Fortune, “Now we have the chance to exercise research on GMOs and work on GMOs imported from abroad”. This paper evaluates contemporary genetic engineering agricultural enhancement research and identifies Ethiopia's gaps.

II. LITERATURE REVIEW

Crop Improvement and GMO Development

agricultural enhancement uses genetic diversity to improve agricultural plant properties. Until the end of the 19th century, crop genetics were changed via time-consuming phenotypic selection in the field without understanding of inheritance processes or genotype-to-phenotype relationships. Breeders have employed scientific ways to enhance genetic variety and manage the relationship between purposeful genetic modifications and phenotypic features since genetics and contemporary plant breeding were invented. Mutations caused by radiation or chemicals revolutionized the first mentioned and gave the world at least 3240 improved varieties of all our major crops, while genetic modification and genome editing have greatly improved the ability to generate genetic variation and control breeding.

Plant breeders selected for favorable qualities using plant DNA once genetics became more known. Traditional plant breeding crosses and selects better genotype combinations to change plant genetics. Plant breeding has been done for centuries and is being utilized today. Plant breeding is useful yet limited. First, only sexually mated plants may breed. This inhibits the species' ability to add new characteristics. Second, when plants mate, various features are conveyed, including yield-reducing ones.

Genetic engineering directly alters an organism's genome, which contains its DNA properties. Engineers can give organisms desired traits by changing the genome. GMOs are genetically engineered organisms.

All genetic alterations impact protein synthesis. Genetic engineers may change organism properties by modifying protein production. Genetic modification may be done by introducing new genetic material randomly or in selected areas, replacing genes (recombination), removing genes, or mutating genes.

Process of Plant Genetic Engineering

Genetic engineering is new. Adding foreign genes to an organism's DNA is intentional. A gene encodes a characteristic. Traditional plant breeding has constraints, whereas genetic engineering does not. Genetic engineering removes DNA and transfers genes for one or a few features to another creature. The'sexual' barrier between species is broken by not crossing. Thus, plants may inherit qualities from any living thing. A single characteristic may be added to a plant, making this procedure more specialized.Five stages are needed to complete genetic engineering. Genetic engineering begins with DNA extraction. DNA must be extracted from the organism to be used. The DNA of an organism with the gene of interest is removed in many phases. Cloning is the second stage in genetic engineering (Berg and Mertz, 2010).

All organism DNA is extracted at once during DNA extraction. Scientists clone a gene of interest and create thousands of copies. Genetic engineers construct a cloned gene to operate in a different creature in the third phase. In a test tube, enzymes snip the gene and replace isolated sections. Use restriction enzymes to break DNA into fragments and gel electrophoresis to sort them by length to isolate the gene. A gene fragment may be amplified by polymerase chain reaction and extracted by gel electrophoresis. A genetic library may include the desired gene or donor organism's genome if it has been properly investigated. Synthesize the gene if the DNA sequence is known but no copies are available.

The changed gene is ready for transformation or gene insertion, the fourth stage. Since plants contain millions of cells, inserting the transgene into every one is difficult. Therefore, tissue culture propagates callus masses of undifferentiated plant cells. These cells will get the new transgene. Various methods inject the new gene into certain cells. Gene gun, agrobacterium, microfibers, and electroporation are typical approaches.

Gene gun: Microscopic gold or tungsten pellets bearing transgene fragments are blasted into plant cells or tissues at high velocity. A tiny percentage of pellets pass through cells, leaving the DNA fragment to form a plant chromosome in the cell nucleus.

The soil-dwelling bacteria Agrobacterium tumefaciens transfers part of its DNA into plants and produces crown gall disease. Genetic engineers have used this DNA transfer method to disable disease-causing characteristics. Plant and

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bacterial cells are co-cultivated in a petri dish for gene transfer. This permits gene insertion more precisely than the gene gun, but not in all plant species.

Transgene insertion is inefficient, with just a few percent of plant cells or tissues being successful. Several methods are used to identify the tiny fraction of cells/tissues that have transformed. Next, turn those cells or tissues into seed-producing plants. Tissue culture involves growing plants on agar or another media with plant nutrients and hormones under controlled circumstances.

Each approach aims to carry the new gene into the cell nucleus without destroying it. Transgenic plants are grown from transformed plant cells. Greenhouse-grown transgenic plants generate transgene-containing seed, which is harvested. Genetic engineer's duty is done. They will provide transgenic seeds to a plant breeder for the last phase.

Backcross breeding is the fifth and last step in genetically engineering crops. Traditional plant breeding is used to cross transgenic plants with elite breeding lines to combine the desirable features of elite parents and the transgene. A high-yielding transgenic line is created by repeatedly crossing progeny to the elite line. The new transgene will produce a plant with yield potential similar to present hybrids. The genetic engineering technique is same for all plants. All five phases take different amounts of time depending on the gene, crop species, resources, and regulatory permission. An innovative transgenic hybrid may take 6-15 years to be cultivated in commercial areas.

Application of Genetic Engineering to crop improvement.

GE's first and most profitable usage was insecticide and pesticide resistance in field crops. To maintain production under shifting environmental circumstances, crop cultivars with environmental stress tolerance are of major interest. Several transgenic cultivars with fortified nutritional properties have been introduced to address hunger in impoverished nations and fulfill naturalists' eating preferences. Developing crops with industrial chemicals and using plants as medicinal hosts have also proved successful. Sustainable agriculture and feeding the growing world population need ways to overcome severe circumstances including water and nutrient stress, high temperatures, and compacted soils with high impedance that significantly affect crop output. Recent advances in molecular, cellular, and epigenetic mechanisms that orchestrate plant responses to abiotic stress will allow crop plants with better root system architecture and optimized metabolism to increase water and nutrient uptake and use efficiency and soil penetration. We describe such breakthroughs and how they may be leveraged to develop gene transfer or genome editing tools for crop engineering in this study. Genetically developing abiotic-stress-tolerant cultivars has little success. Crops often face several stressors, creating a complex system. New technologies allow transgenic crops to retain high yields under duress. According to, reproductive-stage abiotic-stress-tolerant crops should be studied further in the field.

Recombinant DNA and transformation enable plant breeders to develop crops using genes from almost any source. Scientists utilized genes from daffodil, pea, bacteria, and virus to make "Golden Rice" with beta-carotene. These four well-characterized genes may be put into a transgenic plant to modify just the characteristic of interest. When breeders utilize extensive crosses to transmit a desirable gene from a wild plant to a crop plant, numerous unknown genes are introduced.

Transgenic breeding transfers genes across taxonomic boundaries, unlike traditional breeding, which only transfers genes from closely related species. It also allows for faster plant development than traditional breeding and the incorporation of novel genes without incompatibility issues. Genetic engineering is used in plant breeding in the following ways.

- **Herbicide resistant**: Transformation of cereal crops with Glyphosate-resistant gene. Commercial production of herbicide-tolerant soybean and canola.
- **Insect resistant**: Genes from the soil bacteria Bacillus thuringiensis are present in crops that are resistant to insects. Mammals are not affected by the protein that the Bt gene produces in the plant, but it is poisonous to a certain class of insects, such as the European corn borer and corn rootworm. The genes that cause Bacillus thuringiensis to produce delta-endotoxin are used as a biological pesticide. Numerous crops have benefited from the transgene, including soybeans, groundnuts, sunflowers, semi-looper resistant castor, and sunflowers with resistance to head borer infestations. Brassica and safflower were given the snowdrop lectin gene to make them resistant to aphids.

- **Resistance against viral infection:** Tobacco Mosaic Virus coat protein gene was introduced to create agricultural plant variants that are resistant. The resistant types evolved in agricultural plants such as sunflower, which acquired resistance against bud necrosis, groundnut, and clump and stripe viruses, and soybean, which developed resistance against yellow mosaic virus.
- **Resistance against bacterial and fungal pathogens**: Contrary to groundnuts, which were introduced to prevent leaf spot and alternaria blight, and castor to provide resistance to botrytis, chitinase genes were transferred to crops such as brassica, soybean, sunflower, sesame, and so on in order to combat alternaria leaf spot disease. In order to treat the tobacco wildfire disease brought on by pseudomonas syringae, the acetyl transferase gene was transplanted.
- **Improvement of the nutritional qualities in crop plants:** Rice grains have received the beta-carotene gene from daphdils in order to increase their beta-carotene content and help children who are blind. In order to reduce the amount of erucic acid and, in the case of linseed, linolenic acid, the Antisense Fae 1 gene was introduced to Brassica napus and Brassica juncea. To lower the amount of ricin and RCA endosperm in castor seeds, an antisense ricin gene was given to the plant. Sunflowers were injected with antisense sterol desaturase + ac1 to produce varieties with high oleic acid content.
- **Improvement of crop plants against abiotic stresses**: transcription factor genes, structural genes, regulatory genes were introduced into the groundnut, soybean, Brassica juncea, B. napus to develop drought and salinity tolerant types.
- **Development of transgenic male sterile lines:** By transferring the Barnase gene from bacteria to safflower Brassica juncea, transgenic male sterile lines were created. The introduction of genes necessary for agricultural plants to fix nitrogen is a long-term objective in agriculture.

In order to include these crops in the group of crops that may be genetically engineered, trustworthy techniques for the genetic engineering of agricultural plants must be established. The biggest difficulty facing agriculture is increasing food grain production and eliminating the hunger issue in emerging nations; ideally, this method will be implemented in the areas with the worst food shortages. It is necessary to design transgenic plants that are safe and effective after taking into account the health perspective and the current issues faced by farmers. In order to achieve this, more research must be done on a national and worldwide scale to make sure that biotechnology brings about a second, sustainable, and productive agricultural revolution. The existing synergy between conventional and genetically modified plant breeding has to be further enhanced.

Ethiopian Perception to Genetically Engineered Crops.

When used properly, genetic engineering provides a number of advantages by enforcing strict biosafety standards that address food safety and environmental issues. There were no national regulations governing genetic engineering research or the use of genetically modified organisms until recently. Ethiopian scientists were deterred by this state of affairs from starting genetic engineering projects and from taking part in related network activities at the regional and international levels. As a result, the country's modern biotechnology research and development process suffered a major setback in terms of research and capacity building.

Ethiopia is about to become one of the few nations in Africa to sell and produce at least one genetically modified crop, after years of resistance to the technology. After years of internal government wrangling and debate, Ethiopia's Parliament finally adopted an amendment to the Biosafety Proclamation in June 2015. The amendment's primary goal was to establish the legal framework necessary to permit farmers to plant biotech cotton in order to meet the growing demands of the country's rapidly growing textile and apparel industry. The previous Proclamation effectively prohibited both biotech research and the cultivation of genetically engineered crops.

The parliament's adoption of the biosafety bill, a significant move by the Ethiopian government, is anticipated to promote genetic engineering research and responsible product marketing inside the nation. Using crops genetically altered for particular features and tailored to local circumstances, a broad variety of agricultural production issues that are either difficult or impossible to address using standard research methodologies are expected to be handled. Table 1 lists the main obstacles to Ethiopian grain production that genetic engineering may help with. Some of these restrictions can be overcome using commercially available transformation technology that has already been established elsewhere and only has to be introduced and adapted to the local environment with the least amount of professional assistance.

For instance, the private sector has recently shown a strong desire to introduce Bt cotton in order to increase output and feed the nation's expanding textile industry. Due to the pressure of a high boll worm infestation, many cotton-producing farmers in western Ethiopia are giving up on their cotton fields; their efforts will assist increase Ethiopian cotton output. Engaging in partnerships with for-profit businesses like Monsanto makes it extremely simple to get such technology. By using these transgenic plants as parents, traditional breeding may also be used to transmit the desired genes to regionally chosen cotton cultivars. On the other hand, local infrastructure and labor resources for genetic engineering technologies must be developed in order to overcome limitations on native crops like tef and enset that are uninteresting to international businesses.

III. CONCLUSION

Genetic engineering is a potent tool that may be used to change a crop plant's genetic composition. Recombinant or transgenic DNA technology is used to do it. Crop plants possess several desirable traits, but their limited area and output are caused by the presence of one or a few undesirable traits. This forces the farmers to switch crops against their will. Additionally, transgenic technology aids in the efficient mitigation of the malnutrition issues that a vast majority of people worldwide face. Additionally useful in resolving issues brought on by biotic and abiotic stressors is recombinant technology.

Transgenic technology, which identifies and isolates the gene of interest, assists in transferring desirable traits from diverse sources to necessary agricultural plants in order to solve all of these issues. The transgenic method of genetic alteration is more focused and allows for easy tracking of the implanted genes. Unlike the green revolution, which focused just on three key crops and had mixed outcomes, the gene revolution is a technological and ethical breakthrough that may be used to improve the traits of all targeted plants, resulting in substantially greater societal consequences.

Genetic engineering is a contemporary technology used by plant breeders to expedite the breeding processes, not a replacement for traditional plant breeding. Agrobacterium-mediated transformation of plants with glyphosate-resistant genes produced herbicide-resistant cultivars of maize, tobacco, cotton, and other crops. Genetically modified crops with unique genes and favorable traits, such as increased yields, resistance to herbicides, insects, and diseases, drought, salinity, and others, were produced by transgenic technology.

Ethiopia is adamantly opposed to the hurried introduction of genetically modified crops because, as a crop diversity center and origin, we understand the benefits of small-scale, locally adapted, biologically varied agriculture. Unless the researcher can demonstrate that there is an advantage to releasing the GMO into the environment, releasing it into the environment is illegal.

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