GENETICALLY MODIFIED CROP: A STORY OF BT COTTON

Dr Jayshree Thaware
Assistant Professor & Head,
Department of Botany,
S. K. Porwal College of Arts and Science and Commerce, Kamptee Dist- Nagpur

---

Introduction:-

Genetically modified crops (GM crops) are plants utilized in agriculture, the DNA of that has been changed using recombinant DNA technology. Plant genomes can be engineered by physical methods or by use of *Agrobacterium* (a soil bacterium) for the delivery of sequences hosted in T-DNA binary vectors. In most cases, the aim is to introduce a new attribute to the plant that doesn't occur naturally within the species. Examples in food crops include resistant to certain pests, diseases, environmental conditions, reduction of spoilage, resistance to chemical treatments (e.g. resistance to herbicides, fungicides), or rising the nutrient profile of the crop (Wikipedia). GM crops were prepared and manipulated in the laboratory through the Genetic Engineering Technology. Genetic engineering is a product of Biotechnology. We can simply define Biotechnology as a set of tools that uses cellular and molecular processes to solve problems or make/build products.

What is Genetic Engineering?

Genetic engineering is a set of technologies used to change the genetic makeup of cells, including the transfer of genes within and across species boundaries to produce improved or novel organisms. The techniques involve sophisticated manipulations of genetic material and as well as biologically important chemicals.

Genes are the chemical blueprints that determine an organism's traits. Moving genes from one organism to another transfers those attributes. Through genetic engineering, organisms can be given targeted combinations of new genes—and therefore new combinations of traits—that does not occur in nature and, indeed, cannot be developed by natural means. Such an approach is totally different from classical plant and animal breeding, which operates through selection across many generations for characters of interest. Classical breeding operates on traits, solely indirectly selecting genes, whereas biotechnology targets genes, attempting to influence traits. The potential of biotechnology is to rapidly accelerate the speed of progress and potency of breeding.

Why Genetic Engineering?

The process of genetic engineering is faster and more precise than traditional breeding methods alone, allowing the modifications or insertion of specific genes without altering any other traits.

Novel organisms:-

Nature always produces organisms with new gene combinations through sexual reproduction. A brown cow bred to a yellow cow may produce a calf of a completely new color. But reproductive mechanisms limit the number of new combinations. Cows should breed with other cows (or very near relatives). A breeder who desires a purple cow would be able to breed toward one only if the necessary purple genes were available somewhere in a cow or a near relative to cows. A genetic engineer has no such restriction. If purple genes are available anywhere in nature—in a sea urchin or an iris—those genes could be used in attempts to produce purple cows. This unprecedented ability to shuffle genes means that genetic engineers can concoct gene combinations that would never be found in nature. Genetic engineering is therefore qualitatively different from existing breeding technologies. It is a set of technologies for altering or fixing the traits or characters of living organisms by inserting genetic material that has been manipulated to extract it with success from its source and successfully insert it in functioning order in target organisms.

About Cotton:-

Cotton is a soft, fluffy staple fiber that grows in a ball, auto protective case, around the seeds of cotton plants of the genus *Gossypium* in the mellow family Malvaceae. The fiber is almost pure cellulose, an insoluble organic compound crucial to plant structure and is a soft and fluffy material. The cotton plant needs sun for a long period without frost and a good amount of rain. Cotton is a water thirsty crop and needs handful irrigation for its cultivation. It is an important Kharif crop. The word cotton comes from the Arabic word ‘quton’

Cotton is one of an important fiber and cash crops in India as well as of the entire world. Cotton grows in nearly all tropical and subtropical regions around the world including the US, China, India, U'zbekistan Pakistan, Brazil and Turki.

It plays a dominant role within the industrial and agricultural economy of the country. It provides the basic raw material to the cotton textile industry. In India it provides direct livelihood of 26 million farmers and about 40- 50 million people are employed in cotton trade and its processes. In India it is grown on a large scale in Maharashtra, Gujarat, Karnataka, Madhya Pradesh, Punjab, Rajasthan, Haryana, Tamil Nadu and Uttar Pradesh. Gujarat is that of the largest producer of cotton followed by Maharashtra and Punjab.

Conventional Cotton (Non Bt-cotton):-

- Large or giant plant, excessive vegetative growth
- Difficult to spray insecticides, pesticides
- Few bolls to harvest
- More than 10 sprays for all completely different insect-pests

Cotton Problem:-

- Full mature cotton balls (healthy balls) attacked by a caterpillar that is bollworm who bore the cotton balls and tender elements were eaten by the bollworm and destroyed the crop..
- Cotton is attacked by bollworm and the tender parts were destroyed.
- The infective stage is caterpillar.
- Its attacks and bores into top tender or delicate parts of shoots, floral buds and balls.
- Bollworm forms holes and cause premature opening of the Cotton ball which leads to poor lint.
- Protective sprays of insecticides is quite expensive

Bt cotton is a genetically modified organism (GMO) or genetically altered pest resistant plant cotton variety which produces insecticides to combat bollworm. Bt stands for a bacteria *Bacillus thuringiensis* which produces more than 200 completely different Bt toxins, these Bt toxins are insect specific, each type of toxins kills numerous types of insects, moths, butterflies, beetles, aphids, cotton as well corn bollworms. Bt Cotton is one of all the first crop protection products and genetically modified organism (GMO) also genetically modified pest resistant plant, which produces an insecticide to combat boll worm.

Why Bt-cotton?

- Bt cotton is an insect resistant transgenic crop design to fight the Boll worm
- Small compact plant, Many mature bolls ready for harvest, only need 3 sprays for non bollworm pests
- Increases yield of cotton due to effective control of three types of bollworms, viz. American (*Helicoverpa armigera*), Spotted (*Earias vitella*)and Pink (*Pectionphora gossypiella*) bollworms.
- Insects belonged to Lepidoptera (Bollworms) are sensitive to crystalline endotoxic protein produced by Bt gene which in turn protects cotton from bollworms.
- Reduction in insecticide use in the cultivation of Bt cotton in which bollworms are major pests.
- Potential reduction in the cost of cultivation (depending on seed cost versus insecticide costs).
- Reduction in predators which help in controlling the bollworms by feeding on larvae and eggs of bollworm.
- No health hazards due to rare use of insecticides (particularly who is engaged in spraying of insecticides).

Who Invented?

US based Monsanto company scientists inserted a toxic gene from the bacterium *Bacillus thuringiensis* in to cotton plant to create a caterpillar resistant variety. The first field trials were done in US in 1993, and the seeds commercially supplied in 1995. A joint venture in 2002 between Monsanto and Mahyco introduced Bt cotton in India.

How BT Cotton is developed?

BT Cotton was created by genetically altering the Cotton genome to the bacterium *Bacillus thuringiensis.* The transgene inserted into the plant genome produces toxin crystals that are (crystal is insecticidal proteins or cry proteins) that the plant would not normally produce. When a pest feeds on the Bt plant, the protein binds to epithelial cell receptors in the insect's mid gut, these toxins dissolves the gut lining (mid-gut lining) and due to alkaline pH of mid gut of pest the inactive toxin get activated and produces the holes on epithelial cells of the mid gut, leading to the lyses and ultimately death of organism (bollworm).These proteins must bind to specific receptors in the pest's gut to work. Other organisms such as humans, other mammals, beneficial insects and spiders don't have those receptors and are unaffected.

Manipulation of Bt gene:-

Following steps are involved for gene manipulation;

Isolation of Bt gene from *Bacillus thuringiensis*

Incorporation into a vector and cloned and then incorporated into a cotton plant to express it.

Now this crop plant produces cry protein

Choice of gene depends on the crop and targeted pest

Bt toxin are insect specific group.

Cry I Ac and Cry II Ab these two genes affects the cotton bollworm.

Process to make Bt cotton

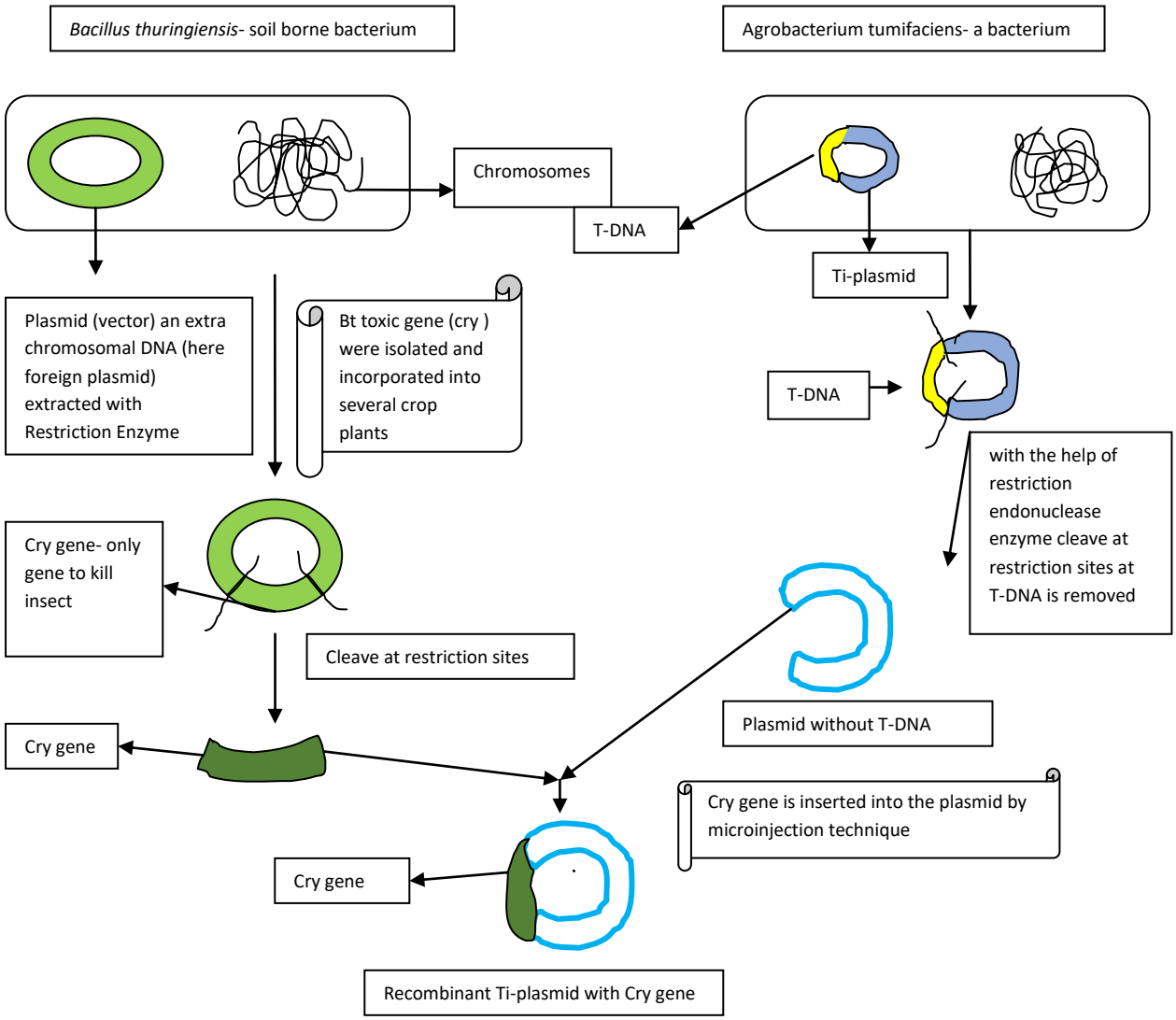


Fig: 1 Steps involved in *Agrobacterium* mediated gene transfer

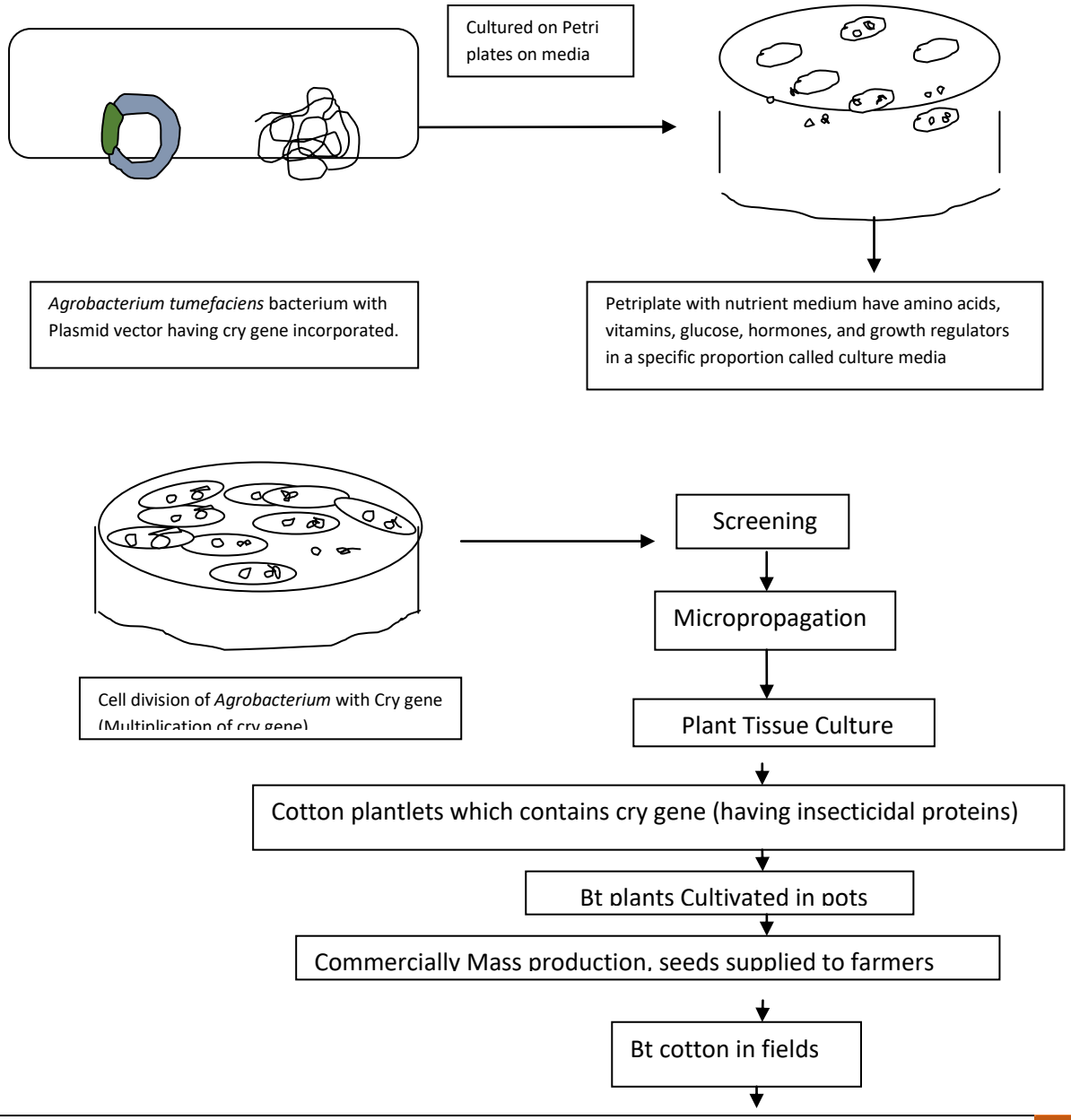
Genetically modified plants have been engineered for scientific research, to create new colors in plants, deliver vaccine, and to create enhanced crops. Plant genomes can be engineered by physical methods or by use of Agrobacterium for the delivery of sequences hosted in T-DNA binary vectors. Many plant cells are pluripotent, meaning that a single cell from a mature plant can be harvested and then under the right conditions form new plant. This ability can be taken advantage of genetic engineers; by selecting for cells that have been successfully transformed in an adult plant a new plant can then be grown that contains the transgene in every cell through a process of Tissue Culture

Types Of Bacteria Are Used:-

Agrobacterium tumefaciens is a gram-negative soil bacterium that used horizontal gene transfer to create tumors in plants. *Agrobacterium tumefaciens* is a plant pathogenic

bacterium that causes tumors (crown gall disease) has been extensively used as major agent for the production of transgenic plants in a wide variety of plant species. The bacterium contains a plasmid (tumor inducing or Ti plasmid), part of which (the T-DNA) integrates into the host plant chromosomes. The Ti plasmid contains several genes including the *vir* genes which control the process of infection of the plant and transfer the DNA to the chromosomes. Plant genomes can be engineered by use of Agrobacterium for the delivery of sequences hosted in T-DNA binary vectors. Due to quality *Agrobacterium* is vastly explored in biotechnology as a means of inserting foreign genes in the plants.

Bacillus thuringiensis is a gram –positive, soil dwelling bacterium commonly used as biological pesticides. Many Bt strains produces crystal proteins called δ-endotoxins (called crystal proteins or Cry proteins),which are encoded by *cry* gene ,that have insecticidal action this led to their use as insecticides in genetic engineering to produce genetically modified crops using Bt gene such as Bt cotton, Bt corn etc. In most of the *B thuringiensis*, the *cry* genes are located on a plasmid (extrachromosal DNA).



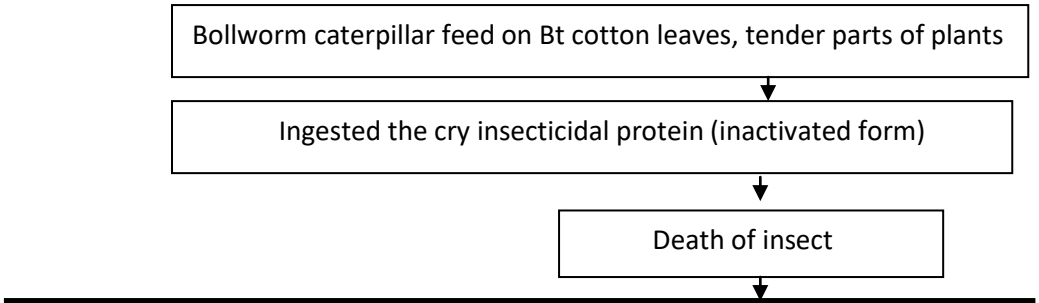


Fig: 2 Process to make Bt cotton plant and mechanism of action

Why Bt crops not used alone to manage pests?

Although, Bt crops have helped managed pests for over 20 years they are losing their effectiveness against some pests. There are couple of reasons, first is Plant variability and Insect variability.

Plant variability:- First goal of Bt crops is to kill the target insects that feed on them. This was not always achieved due to natural variability to the levels of Bt protein within a plant. This means that some tissues in a plant may not have lethal levels of the protein.

Insect variability:- Insect populations are also variable with time. Some insects are naturally less susceptible to certain Bt proteins. They will survive and reproduce, while the majority of the population dies. This is how the resistance developed, and resistance can always develop with any long term pest management approach, including Bt crops

Farmers can slow down resistance with an Integrated Pest Management Stratergy, or IPM.

What is Integrated Pest Management?

It is a long term approach that uses multiple pest management tools. As a result, no single approach to managing pest should ever be seen as a standalone tool. But instead, should be part of a larger strategy. Some of them are Scouting, Crop rotation, Insecticides and Refuge planting.

- **Scouting:-** The only way to know what pests are in the field and how much damage they have caused is by walking out into your field and looking. Once you have accurate information about your pest problem, then one can develop a plan of attack.
- **Crop rotation:-** Avoid planting Bt crops in the same field two years in a row. One can use non Bt varieties of the same crop or yet grow a different crop in alternating years. Either this way plant gives the insects less exposure to Bt protein and develop slow resistance. If field has low pest populations, avoid using Bt crops until scouting indicates a significant pest problems.
- **Insecticides**:- Insecticides can be used in place of Bt crops to manage many pests. Insects can also develop the resistance to insecticides. They should be rotated and used only as part of larger pest management strategy.

- **Refuge planting**:- Refuge planting is mandatory. It involves planting, the part of each field with a non- Bt hybrid of the same crop. Some bags of Bt seeds have non Bt seeds mixed in to create refuges. This allows some non-resistance insects to survive and mate with any resistant insects in the vicinity and producing non-resistant offspring. However, there is a need to create a separate refuge depending on your location.

None of these tools should be used in isolation, and every tool requires vigilance, including Bt crops. Resistance is inevitable; one should always need to pay attention to pest activity. The only way these problems will be discovered is if someone is in the field looking for them, look for unexpected plant damage and an increase in the number of pests based on one's past experience. If so, it's time to get other professionals involved to determine the nature and extent of the problem. Extension educator and local seed sales representatives will be able to help. Socio-economic surveys confirm that Bt cotton continues to deliver significant and multiple agronomic, economic, environmental and welfare benefits to Indian farmers and society including halved insecticides requirements and a doubling of yield.

Conclusion:-

Bt cotton is a genetically modified cotton variety, which produces an insecticide to bollworms. Bacterium *Bacillus thuringiensis* produce different toxins are insecticidal to the larvae of cotton bollworms. The gene coding for Bt toxin has been inserted into cotton to produce this natural insecticide in its tissue. It is ineffective against many cotton pests such as plant bugs, stink bugs and aphides.

Advantages:-

- It increases production (yield) of cotton.
- It protects cotton balls from infection by bollworms.
- It reduces the spraying of insecticides.
- It reduces the predators.
- No side effect on humans and cattle health.
- Integrated pest management was becoming more effective due to low use of pesticides.

Disadvantages:-

- High seed cost of Bt-cotton
- Its effectiveness is up to 4 months, after that the efficiency of the Bt gene drastically reduced.
- In- effective against other sucking pests.
- Disturbing the biological cycle.

References:-

- Aneja K R 2012. Experiments in Microbiology,Plant Pathology and Biotechnology. New Age International Publishers, India. ISBN:978-81-224-1494-3
- Choudhary B, Gaur K 2010. Bt Cotton in India: A country profile ISAAA. Series of Biotech Crop Profiles. Ithaca,NY.
- Government of India, Directorate of Cotton Development 2017. Status paper of Indian Cotton. CICR, Nagpur. https://www.nfsm.gov.in/StatusPaper/Cotton2016.pdf
- Jain V K 2017. Fundamentals of Plant Physiology. S. Chand and Company Limited, New Delhi. ISBN:81-219-0462-5
- Menon M and Uzramma 2017. A Frayed History- The Journey of Cotton in India; Oxford University Press, New Delhi.
- Pandey B P 2015. Botany for Degree Students. S. Chand and Company Limited, New Delhi. ISBN:81-219-2845-1
- Pandey B P 2018. Modern Practical Botany Volume III Plant Physiology and Biotechnology S. Chand and Company Limited, New Delhi.
- https://en.wikipedia.org/wiki/Genetically_modified_crops