**GENETICALLY MODIFIED CROPS AND ITS IMPACT ON ENVIRONMENT**

Samarjit Bhuyan (Author1)

Asstt. Teacher,

Khardhara N.S.S.M.E.M Barpeta,Assam;India samarjitbhuyan126@gmail.com Swarupa Bhattacharjee(Author2) Asstt. Professor,

Deptt. Of Zoology, Bahona College Assam,India bhattacharjeeswarupa@gmail.com

**Abstract**

Genetically modified crops are the crops whose DNA has been modified. This modification is mainly to make the crop resistant to insecticides, herbicides or other such conditions. This is done by the technique of Genetic Engineering where the desired part of DNA is altered. Sometimes a piece of extra specific DNA can be added to the original one. This causes the desired gene to express the desired character and the plant become fit to survive or give the desired result as well. Plants that have been genetically engineered to possess certain desirable traits can include increased resistance to pests, diseases or herbicides, improved nutritional content, and enhanced tolerance to environmental conditions such as drought or salinity. But despite of all these characters there may be some negative impact also. To find this answer, researchers are performing various experiments to ensure that the negative impact on environment should be reduced. They have found that Genetically Modified Crops are instead making the environment more healthy as it reduces many activities such as use of dangerous insecticides and herbicides. This can sometime leads to harm non -targeted species but it is negligible. The technology has also facilitated important cuts in fuel use and tillage changes, resulting in a significant reduction in the release of greenhouse gas emissions from the GM cropping area.

**Keywords:**

GM crops, GE crops ,GMO, Genetic engineering, Conventional Tillage (CT), GM IR crops, GM HT crops, Bt. Crops

I. **Introduction**

Crops whose genetic structures has been altered or modified for specific purpose are known as Genetically Modified (GM) Crops**.** By the process of Genetic Engineering; scientists are editing the DNA of organisms, transferring specific DNA of one organism to other and modifying the actual genetic construction of the organism( Shetty J Manjunath ,et.al;2018). Now-a-days we are very much familiar with such types of crops or any it’s breed. The reason behind their high popularity in the market is primarily due to commercial benefits. We are well known to the fact that genes are the blueprint of any organism which expresses variety of proteins and helps the organism to perform different functions. But why there is the need of Genetically Modified Organism (GMOs)? Due to the population explosion and reduction in cultivable land, there is a high demand of production. Providing the nutritional requirements , both quantitative as well as qualitative food supply to this huge population Genetically Modified Crops emerged as a revolutionary idea( Shetty J Manjunath ,et.al;2018). Sometimes the natural variety or indigenous variety fails to meet the required amount of products due to various factors which may be natural or anthropogenic. But if we can make them resistant to the changes in their environment, they will be able to meet their actual potential or even more. Here in this chapter, we are going to discuss not only about the productivity of genetically modified crops but their interactions and impacts on the environment. Genetically modified crops, also known as genetically modified organisms (GMOs), are plants that have been genetically engineered to possess certain desirable traits. These traits can include increased resistance to pests, diseases or herbicides, improved nutritional content, and enhanced tolerance to environmental conditions such as drought or salinity (Muhammad A. Nawaz et al ;2017). Despite of its exponential uses there is always a question arises whether these plants (GMOs) are beneficial for the environment, or they are affecting the other components of the environment.

**II.** **Impacts of Genetically modified crops on environment:**

The commercial cultivation of genetically modified (GM) crops have been rising concerns worldwide about potential adverse effects on the environment due to the use of these crops(Sanvido et.al ;2007). Consequently, the risks of GM crops for the environment and especially for biodiversity, it has been extensively assessed before and during their commercial cultivation. However, Scientifically proven data on the environmental effects of the currently commercialized GM crops are available today. . This review focuses on the

1

currently commercially available GM crops that could be relevant for agriculture (i.e., maize, oilseed rape, and soybean), and on the two main GM traits that are currently commercialized are herbicide tolerance (HT) and insect resistance (IR). The informations included in peer-reviewed scientific journals, scientific books, reports from regions with extensive GM crop cultivation, as well as reports from international governmental organizations so far provide no such clam about scientific evidence that the cultivation of the presently commercialized GM crops has caused any kind of environmental harm. Moreover, data related to this interpretation of effects of GM crops on the environment are complex and are controversial(Sanvido et.al;2007). The present review highlights these scientific debates and discussion about the effects of GM crop cultivation on the environment considering the impacts caused by cultivation practices of modern agricultural systems . Genetically Modified Crops remains as a topic of controversy also due to their potential impacts. Since the first genetically engineered crops, or GMOs, for sale to consumers were planted in the 1990s, researchers have tracked their impacts on and off the farm (How GMO Crops Impact Our World; FDA USA) Here we have discussed some key points ;

1. **Reduced pesticide use**:

The ability to resist pests and diseases in genetically modified crops is leading to a reduction in pesticide use, asa result fewer chemical treatments are required. It can also minimize potential harm to environment and improve environmental health( B. Graham et.al;2018).Some crops such as Bt crops, are engineered to produce a toxin that is toxic to specific pests. Consequently, GMOs can potentially reduce the environmental impact associated with pesticide application, such as the contamination of soil, water, and non-target organisms. The fuel savings associated with making fewer spray runs in GM IR crops of maize and cotton (relative to conventional crops) and the switch from Conventional Tillage (CT) to Reduced Tillage or No Tillage (RT/NT) farming systems facilitated by GM HT crops, have resulted in permanent savings in carbon dioxide emissions. In 2018, this amounted to a saving of 2,456 million kg of carbon dioxide, arising from reduced fuel use of 920 million litres. These savings are equivalent to taking 1.63 million cars off the road for one year ( B. Graham et.al;2018).

2. **Herbicide-tolerant crops:**

Some genetically modified crops have been engineered to tolerate specific herbicides, allowing them for more effective weed controls. However, the use of herbicide-tolerant crops can lead to an increased reliance on herbicides, potentially resulting in the evolution of herbicide-resistant weeds (Roger H.,et.al; 2021). This can be detrimental to biodiversity and requires the development of new weed management strategies. Herbicide-tolerant crops have facilitated reductions in the amount of tillage because of the improved and more flexible weed control that they provide. In the United States and Argentina, the use of herbicide-tolerant soybean has been accompanied by a major reduction in tillage. Similar effects have been seen with herbicide-tolerant cotton in the United States. Reductions in tillage bring many environmental benefits, including reducing soil erosion and runoff, maintaining soil fertility, and promoting in-field biodiversity (Roger H.,et.al;2021).

3. **Gene flow and biodiversity:**

There has been a matter of concern expressed regarding the possibility of gene flow from genetically modified crops to nearby non-GMO wild relatives or crops. This could result in the transfer of transgenes to related species, potentially impacting biodiversity and natural ecosystems. Strategies such as buffer zones and isolation distances can be implemented to minimize gene flow and maintain the genetic integrity of non-GMO crops. Hybridization of weeds with herbicide resistant crops have the potential to acquire the herbicide-tolerant trait, although this would only provide an advantage in the presence of the herbicide (ICSU, GM Science Review Panel). Some transgenic traits, such as pest or disease resistance, could provide a fitness advantage but there is little evidence that this happens or has any negative environmental consequences (ICSU, GM Science Review Panel). The development of genetics and management techniques to reduce the possibility of gene flow are in process.

4. **Non-target organisms:**

It has been demonstrated that the GMOs that produce insecticidal proteins, like *Bacillus thuringiensis* (Bt) crops minimize insect pest damage. However, there is a concern that these proteins could also affect non-target organisms, including beneficial insects like bees and butterflies. Extensive testing and regulation are typically implemented to assess the potential risks to non-target organisms before genetically modified crops are approved for commercial use. In particular, extensive laboratory and field research has been generated relative to the assessment of non-target effect in transgenic Bt crops that produce the insecticidal proteins of a ubiquitous bacterium, *Bacillus thuringeinsis (* Naranjo Steven .E.;2014)*.* This body of evidence and the quantitative and qualitative syntheses of the data through meta-analysis and other compilations generally indicate a lack of direct impacts of Bt crops on non-target macro-invertebrates. The statistic also unambiguously demonstrate that Bt crops are significantly less harmful to non-target creatures than the alternative use of conventional insecticides for control of the pest that the Bt proteins are designed to target. Some indirect effects on arthropod natural enemies associated with reduced abundance or quality of Bt target herbivores have been shown, but the ramifications of these effects are unclear (Steven E. Naranjo ;2014)

**5.** **Biodiversity:**

Utilising GM crops can have complicated implications on biodiversity (Peter H. Raven;2010). While the reduction in pesticide use may benefit certain organisms. Because we are completely dependent on biodiversity and economy services now and in the future, protecting them should be a top priority and be taken into account in all human actions. It is to know that the ecological problems related to the cultivation of GE crops is not diffrent to any fundamental way from the ecological problems associated with agriculture in general, except that they usually involve the application of much lower chemical supplement contents and thus tend to leave the environments in and adjacent to where they are grown in better condition than do the conventional ones (Peter H.Raven;2010).

**III.** **Conclusion:**

Crop genetic engineering may result in unintended consequences. There is a need for thorough testing and evaluation to ensure that genetically modified crops do not exert unintended negative impacts on the environment. Long-term research is also essential to assess the sustainability of GMO production and potential ecological impacts. After reviewing the various research works done earlier it can be seen that the environmental benefits of genetically modified crops outweigh any potential drawbacks. It is important to note that the impacts of genetically modified crops on the environment can vary depending on the specific crop, trait, and agricultural practices employed. To ensure safety and minimize potential environmental risks before cultivation regulatory bodies in different countries conduct extensive assessments of genetically modified crops. It focuses on the effects of GM crops on the environment including changes in pesticide use and greenhouse gas emissions since those crops were first widely used for commercial purposes before 22 years. The adoption of GM insect resistant and herbicide tolerant technology has reduced pesticide spraying and as a result, decreased the environmental impact associated with herbicide and insecticide use on these crops. This technology has also facilitated important cuts in fuel use and tillage changes, resulting in a significant reduction in the release of greenhouse gas emissions from the GM cropping area. In 2018, this was equivalent to removing 15.27 million cars from the roads (B. Graham et.al;2018).

**References:**

1.Peter H. Raven;.Environmental impacts of genetically modified (GM) crop use 1996–2018: impacts on pesticide use and carbon emissions.)

2.Intergovernmental Panel on Climate Change Chapter 2: generic methodologies applicable to multiple land-use categories. Guidelines for national greenhouse gas inventories volume 4. Agriculture, forestry and other land use; 2006. http://www.ipccnggip.iges.or.jp/public/2006gl/pdf/4\_Volume4/V4\_02\_Ch2\_Generic.pdf

3. How GMO Crops Impact Our World, Food and Drug Administration; USA 2023.

5. Peter H. Raven; “Does the use of transgenic plants diminish or promote biodiversity?”

6. Steven E. Naranzo; ”Effects of GM Crops on Non-target Organisms”

7.ICSU (GM Science Review Panel).

8.Sanvido and Bigler F;.”Ecological impacts of genetically modified crops: ten years of field research and commercial cultivation”

9. BrookesG, Barfoot P. “Environmental impacts of genetically modified (GM) crop use 1996–2016: impacts on pesticide use and carbon emissions. GM Crops Food. 2018;9(3):109–39. doi:10.1080/21645698.2018.1476792. [Taylor & Francis Online], [Web of Science ®]”.

10.George Morris Centre. Economic & environmental impacts of the commercial cultivation of glyphosate tolerant soybeans in Ontario. Guelph (Ontario): Author; 2004. Unpublished.

11.GalveoA Farm survey findings of impact of GM crops in Brazil 2011. Celeres (Brazil); 2012. Unpublished.

12.Conservation Tillage and Plant Biotechnology (CTIC) How new technologies can improve the environment by reducing the need to plough; 2002. http://www.ctic.purdue.edu/CTIC/Biotech.html

13.American Soybean Association Conservation Tillage Study 2001. <https://soygrowers.com/asa-study-confirms-environmental-benefits-of-biotech-soybeans/>

14.VencillW, NicholsR, WebsterT, SoteresJ, Mallory-SmithC, BurgosN, JohnsonWG, McClelland MR. Herbicide resistance: toward an understanding of resistance development and the impact of herbicide-resistant crops. Weed Sci. 2012;60(SP1):2–30. doi:10.1614/WS-D-11-00206.1. [Crossref].

15.NorsworthyJ, WardS, ShawD, LlewellynR, NicholsR, WebsterT, BradleyKW, FrisvoldG, PowlesSB, BurgosNR. Reducing the risks of herbicide resistance: best management practices and recommendations. Weed Sci. 2012;60(SP1):31–62. doi:10.1614/WS-D-11-00155.1. [Crossref], [Web of Science ®].

3

16.Benbrook C. A review and assessment of impact of genetically engineered crops on pesticide use in the US – the first sixteen years. Environ Sci Eur. 2012;24(1):24. doi:10.1186/2190-4715-24-24. [Crossref].

17.SankulaS, Blumenthal E. Impacts on US agriculture of biotechnology-derived crops planted in 2005: an update of eleven case studies. Washington (DC): NCFAP; 2006.

18.JohnsonS, StromS Quantification of the impacts on US agriculture of biotechnology-derived crops planted in 2006. Washington (DC): National Center for Food and Agricultural Policy (NCFAP); 2007. http://www.ncfap.org

19.KlumperW, QaimM A meta-analysis of the impacts of genetically modified crops. PLoS One. 2014;9(11): e111629. doi: 10.1371/journal.pone.0111629. [Crossref], [PubMed], [Web of Science ®].

20.Fernandez-CornejoJ, WechslerS, LivingstonM, MitchellL Genetically engineered crops in the United States; 2014. USDA Economic Research Service report ERR 162. www.ers.usda.gov [Crossref].

21.QaimM, TraxlerG. Roundup ready soybeans in Argentina: farm level and welfare effects. Agric Econ. 2005;32(1):73–86. doi:10.1111/j.0169-5150.2005.00006.x. [Crossref], [Web of Science ®].

22.PrayC, HuangJ, HuR, RoselleS. Five years of Bt cotton in China – the benefits continue. Plant J. 2002;31(4):423–30. doi:10.1046/j.1365-313X.2002.01401.x. [Crossref], [PubMed], [Web of Science ®].

23.BrookesG. The farm-level impact of herbicide-tolerant soybeans in Romania. AgBioForum. 2005;8(4):235–41. http://www.agbioforum.org

24.Brookes G. The benefits of adopting GM insect resistant (Bt) maize in the EU: first results from 1998–2006. Int J Biotechnol. 2008;10(2/3):148–66. doi:10.1504/IJBT.2008.018351. [Crossref].

25.HutchisonW, BurknessEC, MitchellPD, MoonRD, LeslieTW, FleischerSJ, AbrahamsonM, HamiltonKL, SteffeyKL, GrayME, et al. Areawide suppression of European corn borer with Bt maize reaps savings to non-Bt maize growers. Science. 2010;330(6001):222–25. doi:10.1126/science.1190242. [Crossref], [PubMed], [Web of Science ®].

26.SankulaS, BlumenthalE. Impacts on US agriculture of biotechnology-derived crops planted in 2003: an update of eleven case studies. Washington (DC): NCFAP; 2003.

27.KovachJ, PetzoldtC, DegniJ, TetteJ A method to measure the environmental impact of pesticides. New York’s Food and Life Sciences Bulletin. NYS Agriculture. Geneva (NY): Exp. Sta. Cornell University, 139; 1992 and annually updated. p. 8. http://www.nysipm.cornell.edu/publications/EIQ.html

28.BrimnerT, GallivanG, StephensonG. Influence of herbicide-resistant canola on the environmental impact of weed management. Pest Manag Sci. 2005;61(1):47–62. doi:10.1002/ps.967. [Crossref], [PubMed], [Web of Science ®].

29.KleiterG. The effect of the cultivation of GM crops on the use of pesticides and the impact thereof on the environment. Wageningen (Netherlands): RIKILT, Institute of Food Safety; 2005.

30.BidenS, SmythS, HudsonD. The economic and environmental cost of delayed GM crop adoption: the case of Australia’s GM canola moratorium. GM Crops Food. 2018;9(1):13–20. doi:10.1080/21645698.2018.1429876. [Taylor & Francis Online], [Web of Science ®].

31.PetersonR, SchleierJ. A probabilistic analysis reveals fundamental limitations with the environmental impact quotient and similar systems for rating pesticide risks. PeerJ. 2014;2: e364. PMID: 24795854. http://dx.doi.org/10.7717/peerj.364. [Crossref], [PubMed], [Web of Science ®]

32.KnissA, CoburnC. Quantitative evaluation of the environmental impact quotient (EIQ) for comparing herbicides. PLoS One. 2015;10(6): e0131200. doi:10.1371 / journal. pone. 0131200. [Crossref], [PubMed], [Web of Science ®].

33.Reicosky D. Conservation tillage and carbon cycling: soil as a source or sink for carbon. USA: University of Davis; 1995.

34.RobertsonG, PaulE, HarwoodR. Greenhouse Gases in Intensive Agriculture: contributions of Individual Gases to the Radioactive Forces of the Atmosphere. Science. 2000;289(5486):1922–25. doi:10.1126/science.289.5486.1922. [Crossref], [PubMed], [Web of Science ®].

35.JohnsonJ, ReicoskyD, AllmarasR, SauerT, VentereaR, DellC. Greenhouse gas contributions and mitigation potential of agriculture in the central USA. Soil and Tillage Research. 2005;83(1):73–94. doi:10. 1016/j.still.2005.02.010. [Crossref], [Web of Science ®].

36.DerpschR, FriedrichT, KassamA, HongwenL. Current status of adoption on no-till farming in the world and some of its main benefits. Int J Agric Biol Eng. 2010; 3:1–26.

37.EagleJ, OlanderL, HenryL, Haugen-KozyraK, MillarN, RobertsonP Greenhouse gas mitigation potential of agricultural land management in the United States - A synthesis of the literature; 2012. Duke University Technical Working Group on Agricultural Greenhouse Gases (T-AGG) Report.

38.OlsonK, EbelharS, LangJ. Effects of 24 years of conservation tillage systems on soil organic carbon and soil productivity. Appl Environ Soil Sci. 2013; 2013:10. doi:10.1155/2013/617504. [Crossref).

39.LazarusW F. Machinery cost estimates May 2018, University of Minnesota extension service; 2018. http://www.minnesotafarmguide.com/news/regional/machinery-cost-estimates/pdf\_a5a9623c-636a-11e3-8546-0019bb2963f4.html

40.USDA. USDA CEAP-crop conservation insight August 2016; 2016. https://www.nrcs.usda.gov/Internet/FSE\_DOCUMENTS/nrcseprd1258255.pdf

41.USDA. Energy estimator: tillage; 2014. http://ecat.sc.egov.usda.gov

35.USDA. An online tool for estimating carbon storage in agroforestry practices (COMET-VR); 2014. http://www.cometvr.colostate.edu/

42.CalegariA, HargroveW, RheinheimerD, RalischR, TessierD, De TourfonnetS, GuimaraesM. Impact of long-term no-tillage and cropping system management on soil organic carbon in an oxisol: a model for sustainability. Agron J. 2008;100(4):1013–19. doi:10.2134/agronj2007.0121. [Crossref], [Web of Science ®].

4

43.BakerJ, OchsnerT. Venterea T and Griffis T Tillage and soil carbon sequestration—What do we really know? Agric Ecosyst Environ. 2007;118(1–4):1–5. doi:10.1016/ j. agee.2006.05.014. [Cross ref], [Web of Science ®].

44.AngersDA, Eriksen-HamelNS. Full-inversion tillage and organic carbon distribution in soil profiles: a meta-analysis. Soil Sci Soc Am J. 2008;72(5):1370–74. doi:10.2136/sssaj2007.0342. [Cross ref], [Web of Science ®].

45.Blanco-CanquiH, Lal R. No-tillage and soil-profile carbon sequestration: an on-farm assessment. Soil Sci Soc Am J. 2008;72(3):693–701. doi:10.2136/sssaj2007.0233. [Cross ref], [Web of Science ®]

46.Lal R. Soil carbon sequestration impacts on global climate change and food security. Science. 2004;304(5677):1623–27. doi:10.1126/science.1097396. PMID: 15192216. [Crossref], [PubMed], [Web of Science ®].

47.Michigan State University US Cropland greenhouse gas calculator; 2016. http://surf.kbs.msu.edu.

48.MangalasseryS, SjögerstenS, SparkesDL, SturrockCJ, CraigonJ, MooneySJ. To what extent can zero tillage lead to a reduction in greenhouse gas emissions from temperate soils. Scientific Reports. 2014;4(1):4586. doi:10.1038/srep04586. [Crossref], [PubMed].

49.GianessiL, CarpenterJ. Agricultural biotechnology: insect control benefits. Washington (DC): NCFAP; 1999.

50.QaimM, De JanvryA. Bt cotton and pesticide use in Argentina: economic and environmental effects. Environ Dev Econ. 2005;10(2):179–200. doi:10.1017/S1355770X04001883. [Crossref], [Web of Science ®].

51.Monsanto Brazil. Farm survey of conventional and Bt cotton growers in Brazil 2007; 2008. (unpublished).

52.GalveoA Farm survey findings of impact of insect resistant cotton in Brazil, Celeres (Brazil); 2009 & 2010. Unpublished.

53.SmythSJ, GustaM, BelcherK, PhillipsPWB, CastleD. Changes in herbicide use after adoption of HR Canola in Western Canada. Weed Technol. 2011;25(3):492– 500. doi:10.1614/WT-D-10-00164.1. [Crossref].

54.FisherJ, TozerP Evaluation of the environmental and economic impact of Roundup Ready Canola in the Western Australian Crop Production System. Curtin University of Technology; 2009. Technical report 11/2009. https://www.abca.com.au/wp-content/uploads/2010/01/news\_pdf\_068\_WA\_Curtin\_University\_canola\_study.pdf.

55.Brookes G. Twenty-one years of using insect resistant (GM) maize in Spain and Portugal: farm-level economic and environmental contributions. GM Crops Food. 2019;10(2):90–101. doi:10.1080/21645698.2019.1614393. [Taylor & Francis Online].

56.Asia-Pacific Consortium on Agricultural Biotechnology (APCoAB). Bt cotton in India: a status report. New Delhi (India): ICRASTAT; 2006. Unpublished.

57.BrookesG The potential socio-economic and environmental impacts from adoption of corn hybrids with biotech trait/technologies in Vietnam; 2017. PG Economics, UK. [www.pgeconomics.co.uk](http://www.pgeconomics.co.uk/)

**Abbreviations:**

GMO- Genetically Modified Organism

GE crops- Genetically Engineered Crops

GMIR- Genetically Modified Insecticide Resistant

GMHT-Genetically Modified Herbicide Tolerant

Bt- *Bacillus thuringiensis*

5