OpenAccessPub

Journal of Weather Changes

Review Article

Freely Available Online

Biotechnology: A Panacea To Climate Change Disasters- Brief Review

Ekpa Emmanuel[1,*], Shehu Amina Bature[1], Micheal Erika Nancy[1], Komolafe Muhibat[1], Hassan Madinat[1]

[1]Biology Unit, Faculty of Science, Airforce Institute of Technology Kaduna

Corresponding author:

Ekpa Emmanuel, Biology Unit, Faculty of Science, Airforce Institute of Technology Kaduna, 07036135834.

Keywords:

Climate Change, Biotechnology, Environmental degradation, Nigeria

Received: June 22, 2022

Accepted: Aug 03, 2022

Published: Aug 09, 2022

Abstract

Man's activity and/ or inactivity continually impedes the environment in many ways. Sometimes, these impediments could be negative with catastrophic consequences. Emission of greenhouse gases, desert encroachment, deforestation, global warming, and general environmental degradation by different human practices poses a lot of threat to this planet. It has therefore become imperative to explore novel ways or technologies in checkmating hazards emanating from these disasters. Biotechnology which simply refers to the use of living organisms or their parts particularly microorganisms to produce materials for human and animal consumption comes in handy. The aim of this paper is to do a brief review on the merits of applying this technology in mitigating hazards arising from climate change. Focus will be centered on agricultural and industrial biotechnology more as a result of their involvement in land and environmental related matters. Manipulation of crops via genetic engineering for varieties with stress resistance, phytoremediation, tissue culture of orphan crops, and so many other biotechnological practices will be examined so as to highlight their role in stemming disasters caused by climate change. In conclusion, the paper will attempt to explain the reason why developing countries like Nigeria should also join the global race in curtailing this menace via her indigenous biotechnology.

Introduction

Biotechnology within the context of this paper could simply be defined as the use of living organisms (microorganisms, plants, and animals) or their parts for the production of useful compounds or carrying out of processes [1]. As such, biotechnology involves activities like waste treatment and prevention of environmental hazards, production of commodity chemicals, manufacture of therapeutic compounds like vaccines and antibiotics, and the production of transgenic microbes, plants, and animals. All these examples above fall into one or more classes of biotechnology namely; environmental, medical/

pharmaceutical, industrial, and agricultural biotechnologies. Practices like emission of greenhouse gases, desertification, deforestation, industrial pollution, etc all increase global warming and generally affect the environmental negatively. Due to the broad field of biotechnology and the need to discuss only areas important to climate change issues, this write up will only limit itself to environmental and agricultural biotechnologies. Factors associated with climate change like temperature, rain fall fluctuations, and prevalence of pest and diseases negatively affect agricultural productivity. These distortions gives rise to persistent water scarcity which leads to significant production risk. For example, places that are liable to drought and low rainfall may have to look for crops that withstand such unfriendly conditions. This is where the field of biotechnology positively reduced these effects by using modern genetic manipulations to create novel clones with desirable traits [2]. Modern biotechnology has greatly helped genetically modified crops to counteract the effects of climate change in different parts of the world through practices like production of bio fertilizers and energy efficient farming.

The United Nations Intergovernmental Panel on Climate Change (IPCC) defines climate change as the "mean changes in the climatic conditions of an area or variability of its properties over a period of time "[7]. This report claims that climate change could be triggered by both anthropogenic and natural factors like accent of solar cycles, volcanic eruptions and continental drift [7]. Agricultural activities generally contribute about 25 % to greenhouse gas emissions and serve as a major source of methane (48%) and nitrous oxide (52%) from rice fields for instance [3]. Greenhouse gases sometimes puncture the atmospheric shield leading to increase in temperature. Gases, such as carbon dioxide (CO2), methane (CH4), nitrous oxide, hydrofluorocarbons (HFCs) and sulphur hexaoxide (SF6), are mainly emitted by industries. Over a period of time their concentration in the atmosphere increases causing massive global warming [5].

Climate change mitigation strategies mostly aims at reducing the negative impact human activities exert on land and water bodies. For example, reducing concentration of greenhouse gasses released into the atmosphere by controlling the release of industrial effluents and emissions of radioactive materials may be some steps that will protect the earth from effects of climate change. Furthermore, climate change can be mitigated via reforestation and other sinks (natural absorbents and adsorbents). Biotechnological techniques currently in use for mitigation purposes include tissue culture, bioremediation, biosorption, bioleaching, conventional breeding, molecular marker assisted breeding and genetic engineering. Reduction of carbon emission using bio fuels, carbon sequestration, less use of inorganic fertilizers, etc are other processes. This brief review is meant to x-ray the importance and intervention that biotechnology has brought to deal with potential disasters emanating from climate change issues.

Reduction in Green House Gas Emissions

Agricultural practices like application of synthetic fertilizers to crops, over grazing, and deforestation contribute a quarter of all greenhouse gases (carbon dioxide, methane, nitrous oxide, etc) emitted into the atmosphere. However, the application of biotechnology is one of the most reliable answers tothis menace through the use of energy efficient farming, carbon sequestration and reduced synthetic fertilizer usage[15]. Planting genetically modified crops has been shown to reduce the amount of greenhouse gases emitted into the atmosphere by more than 25%. This is due to the fact that since such crops do not need as much maintenance as regular crops; farmers also do not waste much fuel to power their equipment. (Fares, 2014). The reduction in 2011 alone was equivalent to "removing 27 billion kg of carbon dioxide from the atmosphere or equal to removing 11.9 million cars from the road for one year" [4, 5]. The simple use of genetically modified crops in farming allow farmers to expend less fuel as a result of not demanding to ride on farm equipment for long, leading to a reduction of total carbon emissions into the atmosphere.

Energy Efficient Farming

Currently, green biotechnology which refers to the creation of more fertile and resistant plant resources

by using specialized techniques has been used in eradicating global hunger. This is attributed to the fact that there is production of more fertile and resistant crops that have the ability to withstand biotic and abiotic stress. This technology allow farmers to use less energy alongside environmentally friendly fertilizers in food production which assist in carbon sequestration. Production of bio fuels from both traditional and Genetically Modified (GM) plants such as oilseed, sugarcane, rape seed and jatropha also reduce the adverse effects of pollution as a result of transport activities on the farm by the transport sector. Efficient farming assist in cleaning the atmosphere through planting of perennial non edible oil-seeds thereby directly getting involved in the production of bio diesel for use in the energy sector. These oil when blended with fossil fuels reduce the emission of carbon dioxide greatly [6].

Carbon Sequestration

When carbon containing substances particularly carbon dioxide are removed from the atmosphere, they are said to be sequestered. This phenomena recycle carbon back to the soil and removes it from the atmosphere thereby reducing its concentration. From this point of view, carbon sequestration could be considered as one of the best ways to mitigate climate change impact by depleting the ever increasing concentration of carbon dioxide and carbon monoxide in the atmosphere. One efficient way of doing this is conservation tillage. Here, tillage and planting system covers more than 30% of the soil surface with crop residue after planting to reduce erosion there by enhancing methane. Soil carbon sequestration enhances better cycling of nutrients and prevent nutrient losses among other key benefits to farmers (FAO, 2008).

Reduction in Inorganic Fertilizer Production

Inorganic fertilizer utilization in agriculture has led to contamination of the environment with hazardous toxic chemicals. These kind of fertilizers contribute to the formation as well as release of certain greenhouses gasses like nitric oxide (N2O). Ammonium chloride, Ammonium sulphate, sodium nitrate and calcium nitrate are examples of inorganic fertilizers that are responsible for the formation and release of greenhouse gasses [8]. Biotechnological tecniques assist in reducing the use of synthetic fertilizer by using genetic engineering to fix soil nitrogen through Rhizobium species. Another strategy is planting crops that uses nitrogen more efficiently. An example of such crops is genetically modified Canola which has shown significant reduction in the amount of nitrogen fertilizer that filter into the atmosphere and leach into soil and water ways.

Crop Adaptation Through Biotechnology

In the field of Agriculture, climate change leads to reduction in crop yield due to inadequate rainfall, extreme temperatures, emergence of weeds, occurrence of pest and diseases [9]. One possible way of dealing with such global problem is applying agricultural biotechnologies that combat the negative effects of such changes by using genetic engineering to create clones with drought, stress resistance, and many other desirable traits.

Changes in climatic condition pose a lot of challenge in land and water use. Some of these challenges include abiotic stress, salinity, drought, extreme temperatures and chemical toxicity. These all have their negative impact on agricultural production. The agricultural sector uses about 70% of the available fresh water on earth and this is likely to increase as temperature keeps fluctuating. As a result of this, about 25 million acres of land becomes useless each year [10-16]. It is also estimated that increased salinity in arable land will lead to 30% land uncultivated within 25 years and this number will reach up to 50% by the year 2050. The concomitant effect of all these is increased food shortage and global hunger.

Myco-Biotechnology

Mycobiotechnology is branch of biotechnology that uses fungi to create products. These technique utilize fungi for restoration of affected ecologies. Saikia and Jain (2007) reported that both endo- and ecto mycorrhizal symbiotic fungi together with actinomycetes have been used as inoculants for regeneration of degraded forests. Mycorestoration attempts to use fungi to help in

restoration of ecologically degraded environments. Whether the environments have been damaged from anthropogenic or natural disasters, saprophytic and mycorrhizal fungi can help to navigate it to recovery. Afforestation would indirectly contribute to improved agricultural productivity and food security because forests create microclimates that improve rainfall availability. Moreover, forests act as carbon sinks thereby contributing in sequestration and greenhouse reduction effects for climate change mitigation. Consequently, forestry and agroforestry offer the potential to develop synergies between efforts to mitigate climate change and efforts to help vulnerable populations to adapt to negative consequences of climate change.

Future perspective

Impacts of climate change are so evident now and there is no indication that these will reverse in the foreseeable future. Actions must therefore be taken to adopt timely solution to prevent unpredictable and undesirable outcomes. The world population which is currently at 7 billion, is predicted to increase to 8 billion by 2025 and peak at about 9 billion in 2050. According to some studies, developing countries will need to cultivate 120 million additional hectares of crops for feeding an ever increasing populations. Therefore, modern agricultural science should be made more effective in boosting food production. Efforts should be made to incorporate local and conventional biotechnologies with modern biotechnology approaches within national policies and legal frameworks in order to increase resilience of local crop varieties against changes in environmental dynamics (Stinger et al., 2009).

Conclusion

Agricultural and environmental biotechnology can contribute positively towards climate change mitigation through reduction in greenhouse gas emissions, carbon sequestration, less fuel use through energy efficient farming and myco biotecnology. This measures help to improve agricultural productivity and protect the ecosystem from extreme weather event. Sound application of modern biotechnology will help to counteract climate related problems thereby securing crop production and preventing environmental degradation for fast growing population. An approach to safe applications of modern agricultural biotechnologies will contribute to increase yield, food security and also significantly contribute to climate change adaptation.

References

1. Bogusz, D. (1998). Actinomycorhizal symbioses: Recent advances in plant molecular and genetic transformation studies. Critical Reviews Plant Sciences, 17(1), 1–28. doi:10.1080/07352689891304177
2. Garcıa-Jimenez, P., Just, P. M., Delgado, A. M., & Robaina, R. R. (2007). Transglutaminase activity decrease during acclimation to hyposaline conditions in marine seaweed Grateloupia doryphora (Rhodophyta, Halymeniaceae). Journal of Plant Physiology, 164, 367–370. doi:10.1016/j.jplph.2006.05.018
3. Gill, S. S., & Tuteja, N. (2010). Polyamines and abiotic stress tolerance in plants. Plant Signaling and Behavior, 5:(1, 26–33. doi:10.4161/psb.5.1.10291
4. Gomez-Barbero, G., Berbel, J., & Rodriguez-Cerezo, E. (2008). BT corn in Spain - the performance of the EU‟s first GM crop. Nature Biotechnology, 26, 384–386. doi:10.1038/nbt0408-384
5. Hatfield, J. L., Boote, K. J., Kimball, B. A., Ziska, L. H., Izaurralde, R. C., Ort, D. R,, Thomson, A. M., and Wolfe, D. (2011). Climate Impacts on Agriculture: Implications for Crop Production. Publications from USDA-ARS / UNL Faculty, 1350. https://digitalcommons.unl.edu/usdaarsfacpub/1350
6. Hong, Z., Lakkineni, K., Zhang, K., & Verma, D. P. S. (2000). Removal of feedback inhibition of delta-pyrroline-5carboxylate synthase results in increased proline accumulation and protection of plants from osmotic stress. Plant Physiology, 122, 1129–1136.
7. IPCC. Impacts, Adaptation, and Vulnerability. (2014). Intergovernmental panel on climate change (Eds. J.

Houghton). Cambridge, MA: Cambridge University Press.

8. Jain, S., & Sharma, M. P. (2010). Prospects of biodiesel from Jatropha in India: A review. Renewable and Sustainable Energy Reviews, 14(2), 763–771. doi:10.1016/j.rser.2009.10.005
9. Johnsona, JMF, Franzluebbersb, AJ, Weyersa, SL, & Reicoskya, DC. (2007). Agricultural opportunities to mitigate greenhouse gas emissions. Environ. Poll., 150 (1), 107-124.
10. Kumar, Sandeep, Bansode, Rohini, Malav, Mahesh Kumar, & Malav, Lalchand. (2015). Role of agricultural biotechnology in climate change mitigation. International Journal Of Applied and Pure Science and Agriculture, 1(4), 139-145.
11. Lua, H., Liua, Y., Zhoua, H., Yanga, Y., Chena, M., & Liang, B. (2009). Production of biodiesel from Jatropha curcas L. Oil Comparative Chemical Engineering, 33(5) ,1091–1096. doi:10.1016/j. compchemeng.2008.09.012
12. May, M. J., Gillian Champion, G. T., Dewar, A. M., Qi, A., & Pidgeon, J. D. (2005). Management of genetically modified herbicide-tolerant sugar beets for spring and autumn environmental benefit. Proceedings Biologic Sciences, 272(1559), 111–119. doi:10.1098/ rspb.2004.2948
13. Sallema, R. E., & Mtui, G. Y. S. (2008). Adaptation technologies and legal instruments to address climate change impacts to coastal and marine resources in Tanzania. African Journal Environment Sciences Technological, 2(9), 239–248.
14. Stringer, L. C., Dyer, J. C., Reed, M. S., & Dougill, A. J., Twyman, C., &Mkwambisi, D. (2009). Adaptation to climate change, drought and desertification: Local insights to enhance policy in Southern Africa. Environment Sciences Policy, 12, 748–765. 10.1016/j. envsci.2009.04.002
15. Treasury, H. M. (2009). Green biotechnology and climate change. European Biology, 12. Retrieved from http:// www.docstoc.com/docs/15021072/Green Biotechnology-and Climate-Change
16. Valliyodan, B, & Nguyen, HT. (2006). Understanding regulatory networks and engineering for enhanced drought tolerance in plants. Curr. Opin. Plant Biol., 9 (2), 189-195.