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Review

The role of biotechnology in animal agriculture in an era of climate change

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Animal agriculture is the main source of animal protein, meat, eggs, milk, and other organic products in the global livestock industry. The challenges of climate change in livestock breeding, genetics, productivity and natural resource conservation can be manage using biotechnology. It confers heat, and drought tolerance, pest and disease resistance and induce yield on sub-tropical and tropical animals. Biotechnology in molecular genetics, rumen biology and gene manipulation confer ability on animals to withstand sudden climate differences making products more nutritious, safe and cheap. Assisted biotech diagnostic test has made it possible to identify disease agents in animals and monitor the impact of control programs up to the degree of sub-species, strain and bio-type level. Biotechnology–derived vaccine has become safer and cheaper than conventional vaccines. They offer no risk reversal to virulent form, stable at room temperature and do not require refrigerator storage which is of importance for rural smallholder farmers in the tropics.The technology allows the use of new traits in animal agriculture, improving farmer's ability to manage climate conditions with reduce carbon emission and production cost by decreasing demand on in-field applications. Biotechnology remains a viable tool for unlocking genetic codes and repositioning the global livestock industry in an era of climate change. Its application increases resilience of animal production systems in the face of new climate and disease challenges.

Key word: Role, Biotechnology, Animal agriculture and Climate change.

INTRODUCTION

Animal agriculture is the practice of breeding animals for the production of animal products and for recreational purposes (Ian, 2012).Animal agriculture is the ultimate supplier of animal protein, meat, eggs, milk and other essential organic products in the global livestock industry. Derivatives of this sub-sector are extensively utilized worldwide by several industries for the production of nutritional supplements, vaccines, drugs, and feeds for human benefits, aesthetics and research purposes. Itcontributes significantly to alleviation of hunger, nutrition insecurity, poverty and unemployment in tropical countries (Oni, 2015). It accounts for about 70% employment and livelihood of rural dwellers in most developing African countries.In Nigeria, like other develo-ing countries, there is full interest in animal agriculture as it serves as a sure means to income and food supply and satisfy the demand for domestic-base livestock products. As the pressure to feed the rapidly growing population increases, in the twentieth century, the need to use synthetic chemicals and environmental manipulation to improve agricultural productivity became imminent. This advancement introduced the wrath of global warming and climate change confronting agriculture today. Climate change refers to an increase in average global temperature. Natural events and human activities are believed to be the cause and major contributors to an increase in the average global temperature. Agriculture and other related human activities directly increase the rate carbon dioxide (CO2) accumulation in the atmosphere. The Intergovernmental Panel on Climate Change (IPCC, 2014) has reported that farming is responsible for over a quarter of total global greenhouse gas emissions. This suggests that the world is likely going to suffer serious effect of climate change if

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appropriate technologies and strategies are not employed early with the increasing agricultural and human activities in recent time.Agriculture is currently experiencing adverse climate conditions with negative impacts on animals, cultivated crops and plants. The effect of climate change in animal agriculture can be vast. It is expected to reduce animal agricultural productivity, product quality and quantity, availability and income all over the world. In the coming decades, millions of people whose livelihood and food security depends on livestock keeping and crop farming are likely to face unprecedented climate conditions. In tropical Africa countries, this means that some stable ecosystem would become increasingly vulnerable because warming will introduce strange pattern of water scarcity and gross increase in the risk of drought with almost total feed resources scarcity. This therefore indicates that both genetic and environmental manipulations to enhance the production efficiency of animals and crops alike to achieve proper feeding of the growing population in an era of climate change will be affected and yield only slowly. One of the techniques that can be utilize to fast track the progress towards achieving full potentials in animal agricultural in most developing countries confronted with climate change is biotechnology. Biotechnology is the use of living organisms and engineering principles to make, modify and to improve animals for specific use. This technique offer opportunity to break genetic codes and develop tools that enable scientists to learn, identify and manipulate genes (DNA) with incredible precision resulting in rapid increase in animal productivity as while as sustaining natural resources.

In the past, genetic progress in livestock breeding programs has relied on breed substitution and on the traditional genetic approach of testing and selection. In recent years, remarkable advances have been made in the use of biotechnology especially in animal agriculture in the tropics where climate presents unusual conditions. Biotechnology in Animal Agriculture focuses on livestock breeding and genetics, husbandry, nutrition, reproduction and health management. Animal agriculture is yet to attain full potential in the global economy. This is because the sub-sector has been faced with several challenges including climate change, productivity, nutrition and health. Proper application of biotechnology in animal agriculture would help establish sound footing for the enhancement of livestock productivity and sustenance of natural resources in the face of harsh climate. This paper examines the role of biotechnology in animal agriculture, major challenges of climate change and the contributions of biotechnology in managing climate change.

Effects of Climate Change in Animal Agriculture

Climate change will cause a shift in the distribution of areas for animal and crop agriculture Ado and Usman (2015). Heat stress sponsored by global warming reduces animal appetite, production and fertility and increase mortality. Climate change also cause havoc to aquatic bodies. It influences temperature, oxygenation, acidity, salinity and turbidity of the sea, lakes and rivers, the circulation of ocean currents, and the prevalence of aquatic diseases, parasites and toxic blooms. Climate change may bring about an increase in low weight of new born animals in developing countries. The relationship between temperature, rain fall and weight indicates that lower level of rainfall and increased number of dry hot days during pregnancy seems to raise the risk of lower body weight of new born (Anonymous, 2015). Low birth weight animals are at increased risk of illness, low productivity and mortality. It leads to sea-level rise with increased frequency and intensity of storm, flood, hurricane, fires, drought and increased frequency of poverty, malnutrition and series of health and socio-economic consequences. The accelerating pace of climate change, combined with global population and depletion of agricultural resources threatens food security globally (IFPRI, (2001). The over-all impact of climate change as it affects agriculture was described by the Intergovernmental Panel on Climate Change(Cunnigham, 1990). and cited by the US EPAto be as follows:

Increases in average temperature will result to increased crop productivity in high latitude temperate regions due to the lengthening of the growing season and reduced crop productivity in low latitude subtropical and tropical regions where summer heat is already limiting productivity; and iii) reduced productivity due to an increase in soil evaporation rates.

Change in amount of rainfall and patterns will affect soil erosion rates and soil moisture, which are important for crop yields. Precipitation will increase in high latitudes, and decrease in most subtropical low latitude regions – some by as much as about 20%, leading to long drought spells.

Rising atmospheric concentrations of CO_2 will boost and enhance the growth of some crops but other aspects of climate change (e.g., higher temperatures and precipitation changes) may offset any beneficial boosting effect of higher CO_2 levels.

Pollution levels of tropospheric ozone (or bad ozone that can damage living tissue and break down certain materials) may increase due to the rise in CO_2 emissions. This may lead to higher temperatures that will offset the increased growth of crops resulting from higher levels of CO_2.

Changes in the frequency and severity of heat waves, drought, floods and hurricanes, It remain a key uncertain factor that may potentially affect agriculture.

Climatic changes will affect agricultural systems and may lead to emergence of new pests and diseases. In 2012, almost 40% of the world population of 6.7 billion, equivalent to 2.5 billion, rely on agriculture for their livelihood were most severely affected (FAO, 2012).

To mitigate these effects, current biotechnological strategies need to be adopted to efficiently produce resilient animals and more food in stressed conditions with net reduction in greenhouse gas emissions.

Role of Biotechnology in Animal Agriculture

The core challenge of climate change adaptation and mitigation in agriculture is to produce; more food, more efficiently, under more volatile production conditions, and reduction in greenhouse gas emission from agricultural production. Biotechnology will play a central role in enabling agricultural producers in this era to meet these core challenges. Several new traits and techniques of biotechnology in animal Agriculture in recent years offer farmers not only increased productivity, but also greater flexibility in managing and adapting to climate change. Traits that confer tolerance to drought and heat, tolerance to salinity – for example, due to rising sea levels in coastal areas, early maturation and high yield has become available in the sub-tropical and tropical animal production(Marshall, 2014). Climate change also breed new pest and disease pressures. The nuances of temperature changes; high to low temperatures could speed up pest and disease growth, and changes the resistance and dynamics of these population. Traits that are resistant to pests and diseases will improve producers' ability to adapt to climate change and reduce cost of production with safe environment. These would help reduce carbon emissions by decreasing demand for pesticides, insecticides and the number of in-field applications. Biotechnology creates set of tools that have produced dramatic improvements in yield and reductions in production and management costs and input use intensity in livestock production. Several animals and crops that have benefited and reduced emissions include genetically modified organisms (GMO) with pest resistance and insecticide tolerance, Brookes and Barfoot (2012). Reports indicates that in 2012, GM organisms (crops) were grown on roughly 12 percent of the world's arable land with a total reduction due to both the direct and indirect emission effects of GM crops of over 26.7 billion kg of carbon dioxide (CO2), or the equivalent of removing nearly 12 million cars from circulation(IPCC, 2014).

The level of increase in livestock production attained over the last decades has resulted mainly from increasing the number of livestock animals (Oni, 2015). However, increase in biological yield is also needed in this period to meet the challenge for projected global future food demand. This makes biotechnology one of the most viable technique for improving livestock and managing climate change in developing countries. Application of biotechnology has improved and help conserve the indigenous genetic resources of animals. Doubled impact has been recorded in the application of biotechnology in animal health, productivity, nutrition, genetics and breeding and sustenance of bioresources to achieve large scale economic impact (Bonneau and Laarveld, 1999). Reproductive, cloning and embryo transfer techniques has preserved endangered animal species an essential component of biodiversity conservation. Animal reproductive biotechnology would be useful in augmenting reproduction in tropical countries, embryo transfer technologies, assisted tic technique, gene manipulation and transfer would be useful to handle and control health issues in developing countries facing climate conditions. Introduction of foreign gene in animal agriculture improves livestock productivity, resistance to parasites and diseases and make agricultural food more nutritious, safe and cheap. This technology is accredited for recent advances as bioenergy, bioremediation, synthetic biology, DNA computers, virtual cell, genomics, proteomics and bioinformatics gaining root in Agriculture worldwide. Biotechnology has become a golden tool for solving global challenges including: climate change, global warming, genetic disorder, hormonal imbalance, global epidemics, fatal diseases, poverty, hunger and the rising petroleum crisis. The role of biotechnology in some areas of animal agriculture as highlighted by Naqvi, (2007) include:

Application in Animal Health

Animal disease is a major and increasing important factor reducing livestock productivity in tropical agriculture. It causes serious reduction in meat quantity and quality, increasing total insecurity, malnutrition and poverty in developing countries. Use of biotechnology in animal agriculture may contribute significant improvement in disease management and control in this era. Gene manipulation has proven to confer ability on small and large animals to withstand harsh and sudden climate differences in tropics. Recent improvement in reproduction efficiency and yields of animal products i.e. meat, milk, wool, eggs, composition of livestock products i.e. leaner meat, feed value of low-quality feeds i.e. straw are some evidence of biotechnology input in animal agriculture in this period of challenging climate conditions.

Animal Diagnostic and Epidemiology

Advance biotechnology base diagnostic test have made it possible to identify disease causing agents in farm animals with strict precision and monitor the impact of disease control program to the degree of diagnostic precision up to sub-species, strain and bio-type level. Biotechnology assisted diagnosis plays key part in better livestock breeding and herd health management. Parenthood can now be instilled with certain physiological and biochemical traits that are deemed to be desirable to certain climate conditions. It offers opportunity to breed

different types of animals that thrives and adapt sufficiently in a challenging environmental condition.

Vaccine production

Advances in recombinant vaccine have provided some advantages in animal agriculture in recent times than the previous conventional methods. It is safer and offers no risk reversal to virulent form and reduced potential to contamination by other pathogen. DNA technology also provides opportunity for the production of vaccines parasites where conventional have failed. Biotechnology –derived Vaccine may be cheaper, safer than traditional vaccines. They are stable at room temperature and do not require refrigerator storage which is of great importance for rural small holder farmers in tropical countries facing climate change.

Rumen Biology

rumen biotechnology has potential nutrition value for ruminant feed stuffs that are fibrous, low in nitrogen and of limited nutritional value for other animal species. Both large and small animals depend significantly on plants for nutrients and survival. Evidence indicated by IFPRI, (2009) reveals that in the coming decades, the chances of survival of animals depending significantly on green pasture for survival will be difficult, because the growth and availability of plants (feed resources) will be greatly challenged by heat and dryness. Biotechnology can alter the amount of protein and carbon dioxide in plants as well as the rate and extent of fermentation and metabolism of these nutrients in the rumen.

Molecular Genetics

The concept of biotechnology in animal agriculture have created sound footing in animal breeding and genetics. It allows for precise identification and mapping of genes and genetic polymorphisms. QTL detection is today use in animal genetics for clear detection and association of identified genes and genetic markers with economic traits.

Also, there is accurate integration of genotypic and phenotypic data in statistic methods to estimate breeding values of individual animals in a population. Marker assisted selection could be applied for breeding programs using molecular genetic information. Sensational achievements in the use of biotechnology in agriculture were made both in animal and crop production. These achievements are summarized in four different ways, DeLucia*et al.,* (2012): enhanced potential for more vigorous growth and increasing yields, increased resistance to natural predators and pests (including insects and disease-causing microorganisms), production of hybrids exhibiting a combination of superior traits derived from two different strains or even different species, and selection of genetic variants with desirable qualities such as increased protein value, increased content of limiting amino acids, which are essential in the human diet, or smaller plant size, reducing vulnerability to adverse weather condition. Biotechnology has helped improve animal productivity, food quality, quantity and processing in developing countries often confronted with climate change (Cunnigham,1990).

Future challenges of Biotechnology application in Animal Agriculture

The challenges that are likely going to limit the future application of biotechnology in animal agriculture for improvement and sustainability especially in an era of climate change include: public distrust, industrial and ethical concern (Kahi and Rewe 2018). Lack of regulatory and bio-safety policies and poor financial support for the development of biotechnology in developing countries (Oni, 2015). Cost-effectiveness of the use of the techniques. Inadequate technical know-how for proper application of the techniques in developing countries. However, to enhance the potential application of biotechnology in animal agriculture both in sub-tropical and tropical countries faced with climate change, there is Need for: massive investment in capacity building both in human and materials. Intensive training, and mass awareness should be strengthened.

CONCLUSION

Animal agriculture is expected to grow tremendously in line with the projected global demand for food in few years to a decade.

The application of biotechnology in animal agriculture must remain central if the world must respond to climate change and the pressure to produce more food for the ever-growing human population. The role of biotechnology in animal agriculture has becomes more visible in the area of livestock productivity and improvement, health management, global food security, economic prosperity and natural resource sustainability. While it is still difficult to predict the precise effect that climate change will have on the global distribution and severity of diseases and unfavorable climatic conditions, creating public awareness and bringing biotechnology techniques closer to rural smallholder farmers in developing countries is likely going to increase the resilience of animal production systems in the face of new climate and disease challenges. Biotechnology remains the most viable revolutionary technology with reliable potential for repositioning the global livestock industry especially in an era of climate change.

RECOMMENDATION

An urgent attention is needed about climate change in animal agriculture. First, there is need for proper application of biotechnology for managing climate change, and the idea of utilizing carbon sink to soak up carbon dioxide. The federal, state, local, international agencies and other development partners are required to fund climate change projects for sustainable solutions. Developing countries especially Nigeria, should embark on programs to make natural gas available for her citizenry. Also, there is need to promote research and establish a commission that would handle issues related to climate change facing animal agriculture in developing African countries. Biotechnology research to mitigate global warming and climate change should be initiated at all levels to sustain the utilization of new products.

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