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Rhizosphere biodiversity as a premise for application in bio-economy

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ABSTRACT

Use of fossil fuel and its products have led to environmental pollution, greenhouse gases emissions, global warming and climate change. In order to mitigate and eradicate these problems, bioeconomy was conceptualized. Bioeconomy is deviation from dependence on fossil fuel to a situation where biomass will not only provide food but also raw materials for the industry including provision of bio-diesel. The major debate about bioeconomy is its sustainability. Sustainable bioeconomy should involve highly developed understanding of genetic materials and cellular reactions to redesign and produce novel methodologies and products. It is suggested that sustainable production system among other factors must minimize the excessive utilization of external resources. It should exploit natural mechanisms like nutrient cycling and release, fixation of nitrogen by bacteria and biocontrol mechanisms. Biomass is required in such magnitude such that sustainable intensification should be the watch word. In dealing with sustainable intensification, soil fertility is a major factor to be considered. In the past, management of soil fertility centered on use of inorganic fertilizers but this has not been sustainable. Use of both living and dead organic matter has been suggested as the means to sustain soil fertility. Living organic matter especially the plant-mediated organisms are known to be high in rhizosphere. Technological innovation in rhizosphere biodiversity is believed to bring about the next green revolution in agriculture. Soil fertility and productivity are enhanced by several soil inhabiting microorganisms such as rhizobia, mycorrhiza, yet maximum crop yield has not been achieved. The exploration, management and manipulation of these rhizosphere organisms are vital to maximizing crop yield. Multifaceted use of inoculum with both biofertilizers and biocontrol abilities are now areas of ongoing research. Specific yield target and site specific multifaceted multi-inoculum production should be the new research strategy.

1. Introduction

Bioeconomy is a teeming terminology in the frontier for green and low or carbon free economy. The shift from dependence on fossil fuel has placed a challenge to develop bio-based economy. In such economy, agriculture will provide quality food for the growing population in addition to raw materials for industries and energy. Such bio-based economies should ensure reduction of greenhouse gases in transiting to the system (Huisingh et al., 2015; Pülzl et al., 2014). It is noted that bioeconomy depends on sustainable agricultural production and utilization of these produce for human and animal consumption and renewal raw materials for industries and fuel (Ingrao et al., 2016). Such sectors that produce and use the produce like agriculture, horticulture, fisheries, forestry, bioenergy and biorefineries should be involved (Koukios, 2015; Lopes, 2015).

At the heart of bioeconomy is biomass production which is the building block for such economy. Without sustainable biomass production, the whole story about bio-based economy will be a mirage. The core in bioeconomy is the continued sustainable production of food and fiber, which is a key priority in fostering innovation for producing quality biomass. It is envisaged that innovations in soil biological fertility are able to sustainably provide future requirement for food stuff, feed, fiber and biofuel (Hatfield and Walthall, 2015). A large proportion of diverse organisms within terrestrial ecosystems are found below ground in soils. And they play a lot of roles in ecosystem services. In plant ecosystem, rhizosphere is a zone with rich microbial composition (Prashar et al., 2014). All aspects of agricultural practices require a better understanding of rhizosphere processes that facilitate plant growth and disease suppression. Therefore studying the intricate relationship between crop, soil and microbes in the rhizosphere is integral for sustaining healthy and high yielding production systems

Rhizosphere diversity is therefore a term to decipher the numerous organisms inhabiting the soil, closest and mostly influenced by plant roots. Plants grow in intimate association with complex

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microorganisms especially within the rhizosphere. Rhizosphere is intersecting of soil, plant and microorganisms and a niche for high microbial activities (Huang et al., 2014; Nicolitch et al., 2016). Hence, it's vital to study microbes in close proximity to plants as a way to elucidate their functions in the environment. Microorganisms that establish symbiotic interactions with plants play significant role in agricultural productivity and thus have potential for application in sustainable production. It is also predicted that the advancement in microbial techniques will lead to the new green revolution. Firstly, this review papered to give dissects of bioeconomy and the significance of soil management in sustainable biomass production. It further enumerates on the role rhizosphere biodiversity plays in fostering sustainable biomass production and the organisms involved in accomplishing these functions. Additionally, this article suggests how inoculum production can be managed and fostered for more efficient biofertilization. It is also observed that there should be site and yield-targeted specific inoculum production. Such inoculum will be a consortium of different organisms for different purposes with the sole aim of achieving specific yield and abundant biomass level. The paper is concluded by reviewing several literatures on biotechnological advancements in rhizosphere diversity.

2. Dissect of bioeconomy; the green economy

In the emerging and challenging global issues of food insecurity, climate alteration, natural resource sustainability and high dependence on manufactured resources, bioeconomy is noted as means to tackle them (Ollikainen, 2014; Staffas et al., 2013).The urgent need to reduce greenhouse gases emission which leads to climate alteration is the major factor driving the interest in bioeconomy (Pätäri et al., 2016). Dependence on fossil fuels for energy generates a lot of these greenhouse gases (Scheiterle et al., 2017). Use of fossil fuel is noted as the major source of CO_2 emission, its burning also generates N_2O (UEPA, 2017). It elaborated that human use of petroleum for light, heat, and movement in the United States constitute the highest greenhouse gas emissions (39%), excluding its use for industries, agriculture and other energy related issues (Fig. 1). So there is need to deviate from their use. More so, another motivating factor in bioeconomy is swift biotechnological advancement in biological sciences, with unique biological products (Global Bioeconomy Summit, 2015).

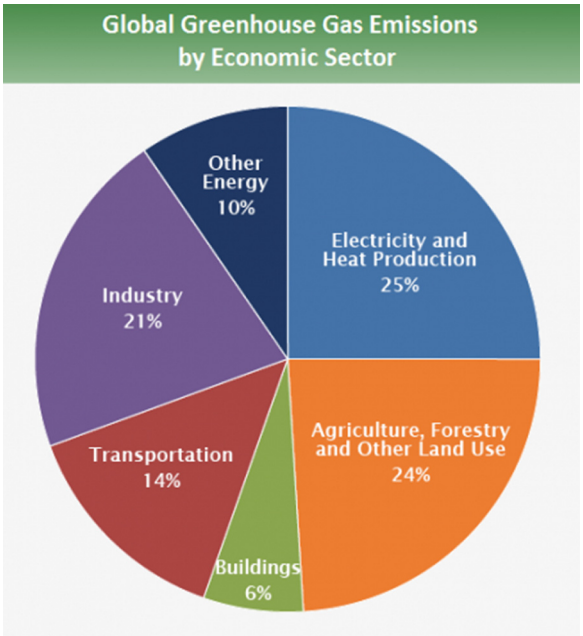

Fig. 1. Global greenhouse emission by economic sector in US. Source: (IPCC, 2014).

So what is bioeconomy? Bioeconomy is defined by European Commission (2012) as an economy using animal and plant resources and their wastes from land and water bodies as raw materials for industry and power generation. In addition, biologically based initiatives to such industries are included (Loiseau et al., 2016). Bioeconomy as a concept according to McCormick and Kautto (2013) has its building blocks derivable from renewable plant and animal resources. Such economy unites the reusable and non-synthetic biological resources with biological mediated processes (Scarlat et al., 2015). The peculiarity in all the definitions is biological resource or biomass as the input in bioeconomy.

Consequently, bioeconomy covers the fields of agriculture related industries including those that use renewable materials as their primary input (Ollikainen, 2014). Furthermore, natural techniques and materials from renewable sources are used in medicine, diagnosis, production of nutrient rich crops, power, chemicals, and materials, for wealth creation and reduction in environmental degradation (Pellerin and Taylor, 2008). As a consequence, bioeconomy will require firstly consistent availability of cheap mechanism for supply of feed stock, which is biomass.

The debate on biobased economy is majorly on its sustainability. The capacity of such a system to sustainably produce food and at the same time produce biomass for the industries and biofuel is very questionable. Moreover, introduction of new crop variety could possibly compete with the available land for food production. And these new crops could introduce new pathogens and pests that may constitute a problem for the food crop species. As a sequel, according to McCormick and Kautto (2013) sustainable bioeconomy should involve highly developed understanding of genetic materials and cellular reactions to redesign and produce novel methodologies and products. Secondly, it should entail the use of renewable biological material and capable biological processes to sustain productivity. Lastly it is suggested that biotechnological knowledge and applications should be integrated across a range of sectors. A bioeconomy entails the use of biotechnology on a large scale.

However, the overall purpose of bioeconomy is transition from petroleum to a total dependence on biomass for food and industry. It also emphasizes biological processes as mediators for bioproducts such as bioethanol, biofuel and other products. The sustainable production and utilization of biological resources should permit more production of crops from the little available resources. And at the same time limit negative impacts on the environment. This will reduce much dependency on petroleum thereby extenuating shift in climate (European Commission, 2012). Accordingly, the sustainable production and exploitation of natural resources contributes to food security, sustainable management of land resource, plummeting dependence on synthetic materials, extenuating and adaptations to alterations in climate, jobs creation and maintenance of competitiveness.

3. Sustainable biomass production

Sustainability is an all evasive term that deals with management systems that will guarantee present and future production. Sustainable agricultural production has been recognized as the solution to myriad of problems facing the globe. These problems include inappropriate use of agro-chemicals and agro-facilities, climate change and global warming. There is real need for innovations in sustainable agricultural management systems. The need for agriculture to generate additional food devoid of environmental deterioration calls for more stringent sustainability mechanisms (Milder et al., 2015; Snapp et al., 2010). The concept of sustainable development tries to reconcile profitability and human development with the working of the natural environment. It is also defined as the production of food and raw materials using techniques that lead to environmental protection. Such system conserves human health and communities and maintains animal wellbeing. It is production of healthy food without comprising future generation. More