

# Threats of Climate Change and Its Possible Solutions Through Utilization of Potential Microbes on Crop Production

Wubayehu Gebremedhin

Ethiopian Institute of Agricultural Research, Fogera National Rice Research and training Center, Woreta,  
Ethiopia  
P.o. Box: 1937 Woreta, Ethiopia

## Abstract

The emission of green house gas in the globe contributes for the occurrence of climate change through changes in temperature, rain fall and climate extremes. Many changes involve microbes that contribute to or amplify human impacts. Since the basic chemistry of Earth's surface is determined by biological activity-especially that of microbes we must look to studies of microbiology to help us understand how and why the Earth is changing and to find solutions for such undesirable changes. Many of related literatures highly indicates climate change threats projected a 50% global temperature increment, yield reduction showing drop of up to 50% from 2050 to 2100. The predicted changes in temperature, precipitation patterns, and CO<sub>2</sub> concentrations in the future could significantly impact the fluxes of soil mineral N and N leaching and also consequences of increases in soil salinity and a decrease in the depth of the water table. Literatures also indicate with the change in climate, the insects, pests and diseases are expected to expand their range and may find new and more vulnerable hosts. However different artificial measures were applied for ultimate goal of maximizing productivity and economic returns, an intimate role of microbes for green house reduction, sustainable soil fertility improvement, control of weeds, pest and plant diseases were reported. The reports indicated that a potential microbe called *Prochlorococcus* and *Synechococcus* remove about 10 billion tons of carbon from the air each year, a mixture of *Bacillus thuringiensis* spores as a pesticide, *B. thuringiensis* accounts for over 90 per cent of the total share of today's bio insecticide market and diazotroph bacteria (*Rhizobium*, *Bradyrhizobium*, *Sinorhizobium*, *Frankia*) through symbiotic association accounted 79% atmospheric N fixation and showed an efficacy as potent plant growth promoters. The cumulative summary of many literatures ensures the capability of replacing artificial measures with biological control measures for climate change threats.

**Keywords:** Greenhouse gases; Bio control; Climate change; Microorganisms

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## 1. INTRODUCTION

### 1.1. Background

Climate change is a major challenge to agriculture development in the world. Climate and agriculture are highly interrelated with affecting each other. Agriculture contributes to climate change on a global scale through emission of greenhouse gases (GHGs) while climate change affects agriculture through changes in average temperatures, rainfall, and climate extremes; changes in pests and diseases conditions; changes in the nutritional quality of foods; and changes in sea level among other (Niang *et al.*, 2014). Climate change is already affecting agriculture and its effects are unevenly distributed across the world (Porter *et al.*, 2014).

Agriculture is expected to pay a significant cost of the damage caused by climate change. According to the Intergovernmental Panel on Climate Change (IPCC) 2007 report, Africa will be the most vulnerable to climate change globally, due to the multiple stresses of poor infrastructure, poverty, and governance. Temperatures are likely to increase by between 1.5-4°C in this century. Projections on yield reduction show a drop of up to 50% and crop revenue is forecast to fall by as much as 90% by 2100.

Climate has a prominent role in Ethiopia. Recent studies have shown that flood hazard is increasing in the highland areas due to changes in land use/land cover, rainfall pattern, and drainage (Kassie, 2014). Depending on local soil conditions and other factors, the 1996 grain harvest was exceptionally good in some areas, whereas in others there was substantial crop failure. Conversely, not all assessments of the impact of climate change in Africa are negative, there are likely to be some positive aspects due to changes in seasons and production cycles. Ethiopia and Southern Africa are expected to have extended growing seasons due to climate change, a consequence of increased temperature and rainfall changes. In addition, the livestock sector could be boosted by temperature increases, according to IPCC models; an increase in 5°C could mean a rise in farmer incomes by up to 58% (Tesfaye *et al.*, 2015). Under unstressed conditions, compared to current atmospheric CO<sub>2</sub> concentrations of almost 380 parts per million (ppm), crop yields increase at 550 ppm CO<sub>2</sub> is in the range of 10–20 percent for C<sub>3</sub> crops and 0–10 percent for C<sub>4</sub> crops (Ainsworth and Long, 2005).

Of course, changes in atmospheric composition are one component of global change, which also includes disturbances in the physical and chemical conditions of the oceans and land surface. However global change has

been a natural process throughout Earth's history, humans are responsible for substantially accelerating present day changes. These changes may adversely affect human health and the biosphere on which we depend. Many changes involve microbes that contribute to or amplify human impacts. Since the basic chemistry of Earth's surface is determined by biological activity-especially that of microbes we must look to studies of microbiology to help us understand how and why the Earth is changing and to find solutions for undesirable changes. Unless we understand better the human-microbe partnership in global change, and better manage activities of organisms that maintain balances in the atmosphere and biosphere, we will find ourselves increasingly challenged by unprecedented environmental problems.

Therefore, the objective of this review paper is to determine and amplify the threats of climate change on crop production, soil fertility decline, pest and disease occurrence as production constraints and to highlight the solutions through utilization of potential microbes.

## 2. Threats of Climate change

Climate change is emerging as a major challenge to agriculture development of Africa. The increasingly unpredictable and erratic nature of weather systems on the continent has placed an extra burden on food security and rural livelihoods. Agriculture is estimated to pay a significant cost of the damage caused by climate change. Progress on rural development has already been hit hard by the combined effect of the global financial downturn and the food crisis; as a result, hunger and malnutrition trends remain stubbornly high. The projections suggest that global temperatures may rise by 0.6–2.5°C by 2050 and 1.4–5.8°C by 2100 (IPCC, 2007a). For South Asia, a 0.5–1.2°C rise in temperature is projected by 2020, 0.88–3.16°C by 2050, and 1.56–5.44°C by 2080, with the variation depending on the scenario of future development (IPCC, 2007a,c). Climate change is responsible to increase temperature and a corresponding decrease in soil humidity, which would result in the tropical rainforest on the eastern side of the Amazon region, is gradually replaced by savannahs (IPCC, 2007a; AGRIFOR, 2009). Further, the semi-arid vegetation will gradually be replaced by arid-land vegetation; significant losses in biodiversity in tropical areas; crop productivity would decrease leading to decrease in productivity of cattle farming.

### 2.1. Impact of Climate Change on Crop Production

The changes in crop production related to climatic variables will possibly have major influences on regional as well as global food production (Abraha *et al.*, 2006). The impacts of climate change on crop yield can be determined either by experimental data or by crop growth simulation models. To predict future impacts on crop yields, crop models present valuable approaches. A number of crop simulation models, such as CERES-Maize (Crop Environment Resource Synthesis), CERES-Wheat, SWAP (soil–water– atmosphere–plant), and InFoCrop (Gbetibouo, 2004), have been widely used to evaluate the possible impacts of climate variability on crop production, especially to analyze crop yield-climate sensitivity under different climate scenarios.

Increasing atmospheric carbon dioxide concentration and simultaneous rises in temperature are influencing the global climate as well as affecting growth, development, and functioning of plants. Increase global yields by roughly 1.8% per decade. At the same time, warming trends are likely to reduce global yields by roughly 1.5% per decade without effective adaptation, with a plausible range from roughly 0% to 4% (Lobell & Gourdji, 2012). Increasing of CO<sub>2</sub> fertilization may reduce the nutritional quality of crops, especially in nutrient-poor cropping systems, through reduced nitrate assimilation and lower protein concentrations in harvestable yield (Taub *et al.*, 2008).

Temperature effects on yield and yield components were highly significant. The number of panicles per plant increased while the number of filled grains per panicle decreased sharply with increasing temperature treatment. Generally higher temperature reduces crop yield through the five causes; first, faster crop development and thus shorter crop duration, which in most cases is associated with lower yields (Stone, 2001). Second, temperature impacts the rates of photosynthesis, respiration, and grain filling. Crops with a C<sub>4</sub> photosynthetic pathway (e.g. maize and sugarcane [*Saccharum officinarum*]) have a higher optimum temperature for photosynthesis than C<sub>3</sub> crops (e.g. rice and wheat), but even C<sub>4</sub> crops see declines in photosynthesis at high temperature (Crafts-Brandner and Salvucci, 2002). Warming during the day can increase or decrease net photosynthesis (photosynthesis-respiration), depending on the current temperature relative to optimum, whereas warming at night raises respiration costs without any potential benefit for photosynthesis.

Third, warming leads to an exponential increase in the saturation vapor pressure of air. Plants respond to very high Vapor Pressure Deficit (VPD) by closing their stomata's but at the cost of reduced photosynthesis rates and an increase in canopy temperature, which in turn may increase heat-related impacts. Fourth, temperature extremes can directly damage plant cells. Finally, rising temperature, along with higher atmospheric CO<sub>2</sub>, may favor the growth and survival of many pests and diseases specific to agricultural crops (Ziska *et al.*, 2010).

Most of the abiotic stressors affecting plant growth (e.g., heat and cold waves, frost events, water shortage) are characterized by dynamics in weather variables for which the crop is not able to provide a suitable physiological response during the most sensitive phenological phases. Concerning the stress caused by water shortage, most of

the existing simulation models include approaches to reproduce soil-water-plant dynamics and the resulting effects on crop productivity (Singh *et al.*, 2006). Water stress during the reproductive period of cereal crops may be particularly harmful (Stone, 2001; Hatfield *et al.*, 2011), while changes in the timing of the rainy season, particularly in tropical areas, may confound traditional techniques for farmers to determine appropriate planting dates.

## 2.2. Impacts on crop pest and disease

Climate change threatens crop yields, both directly through changes in plant growth and production and indirectly through impacts on crop diseases. It has been estimated that changes in climate have already been reducing global agricultural production by 1–5% per decade over the last 30 years (Porter *et al.*, 2014).

The drastically increasing of temperature rise is beneficial to the crops; the extra heat also affects weeds. Weeds, pests, and insects tend to get better living conditions under higher temperatures. To further increase the risks of a good crop, there is also the potential for poor herbicide performance. The multi-combination of the weeds, pests and poor herbicide performance reduces the potential crop yields. The increase in temperature also increases evapotranspiration, which has a negative impact on crop yields (Williams *et al.*, 1988). Pathogens and disease may also be affected by a changing climate. This may be through impacts of warming or drought on the resistance of crops to specific diseases and through the increased pathogenicity of organisms by mutation-induced by environmental stress (Gregory *et al.*, 2009). Plant pests are particularly sensitive to warmer and wetter conditions. The rise in temperature could shorten dormant periods, speed up pest and disease growth and change their dynamics and resistance to pesticides. With the change in climate, the insect pests are expected to expand their range and may find new and more vulnerable hosts. Since temperature directly affects many attributes of insect biology, population responses may vary dramatically in response to anticipated warmer climates. With an increase in range and population of insect pests, the use of pesticides may increase and there will be cascading effects on ecosystems and health. Researchers have shown that increased temperature can potentially affect insect survival, development, geographical range, and population size (Ramamurthy and Sharma, 2009). According to the research studies whenever an increase of 2°C temperature, insects might experience one to five additional life cycles per season (Yamamura and Kiritani, 1998).

## 2.3. Impact of climate change on soil

Soil systems are fundamental to sustainable development due to their multifunctional role in providing services including biomass production (food, feed, fiber, and fuel); habitats for living organisms and gene pools (biodiversity); cleaning of water and air; mitigation of greenhouse gas emissions; contributions to carbon (C) sequestration; buffering of precipitation extremes; and provisions to cultural, recreational, and human health assets (Coyle *et al.*, 2016).

Among the anthropogenic cause of climate change, agriculture is responsible for about 14% of total GHG emission, and these projections can become as high as 30% of total anthropogenic GHG emission if deforestation due to the expansion of the agricultural frontier is included (IPCC, 2007a). On the other hand, the mitigation potential of agriculture (estimated upper limit if best management practices are widely adopted) has been calculated as 5.5–6 Gt of CO<sub>2</sub> eq. per year by 2030 (IPCC, 2007a). This potential is extremely large, especially relative to emissions from the sector. About 89% of this potential could be achieved through soil carbon (C) sequestration.

Unless the mitigation and adaptation strategies incorporated, the shortage of water drives the farmers for the intensive exploitation of groundwater initially benefited the farmers and helped them to attain higher production with consequences of increases in soil salinity and a decrease in the depth of the water table. The predicted changes in temperature, precipitation patterns, and CO<sub>2</sub> concentrations in the future could significantly impact the fluxes of soil mineral N and N leaching (Jabloun *et al.*, 2015).

The impact of changes in climatic variables on nitrate leaching from soils was projected under winter wheat crop land, which indicated that N leaching increased with temperature, particularly for coarse, sandy soils compared to the sandy, loam soils (Patil *et al.*, 2012). Similarly, (Wang *et al.*, 2015) reported that soil nitrate leaching in tile drainage under future climate conditions increased by 34% for a corn-soybean rotation cropping system compared to the historical climate, which was attributed to the reduced corn N uptake.

The effects of climate change are associated with increases in temperature (T) and extreme weather events such as heavy rainfall, droughts, frosts, storms, and rising sea levels in coastal areas. These effects may also increase the threats to the soil such as soil erosion, soil compaction, reduced soil fertility, and lowered agricultural productivity, which ultimately deteriorate food security and environmental sustainability (Lal *et al.*, 2011). These climate-related risks raise major concerns regarding the future role of soils as a sustainable resource for food production.

Soil water can be fluctuated by a number through climate change such as precipitation causing rapid changes in soil water since the time-scale for response is usually within a few hours, temperature increase resulting in

greater evapotranspiration loss of water from the soil and lastly the type of land use.

### **3. Bio control strategies to enhance crop production under the consequences of climate change**

For the ultimate goal of maximizing productivity and economic returns different measures are being applied as an agricultural input. External inputs to agricultural production includes mineral fertilizers such as urea, ammonium nitrate, sulfates, and phosphates; organic amendments such as animal manures, composts, and biosolids; various other biological products such as microbial inoculants, and pesticides including herbicides, insecticides, nematicides, fungicides, veterinary health products, and soil fumigants (Bunemann *et al.*, 2006.). Development of biocontrol to enhance the operational climate change intimidating effect on crop production soil fertility, weed, pest and disease management is long overdue. Therefore, now a day considering of opportunities may be the best we can ever expect. Currently, worldwide about 15–20 weeds are biologically controlled with pathogens (Roskopf *et al.*, 1999) and also the soil fertility and crop productivity is being enhanced through decomposition of crop residues, immobilization of nutrients, mineralization, biological nitrogen fixation, and bioturbation.

#### **3.1. Microbes for green house gas reduction and favoring crop growth**

Climate change is one of the major challenges that affect the life of the plant found on the earth particularly affecting the photosynthesis, root activity, general morphology and functioning of plant specimens as well as their interactions (P. N. Bhattacharyya *et al.*, 2016). Anthropogenic activities and agriculture have stimulated the production of greenhouse gases (Hunter, 2008). Soil microorganisms contribute significantly to the consumption of greenhouse gases (Bardgett *et al.*, 2008), including CO<sub>2</sub>, methane (CH<sub>4</sub>), nitrous oxide, and nitric oxide (NO). However the extents of effects are unknown as concentration of these gases continues to raise, soil microbes exhibit feedback responses that accelerate or slow down global warming.

For such instances, an elevated temperature increases both methane and CO<sub>2</sub> emissions leading to further increases in warming. Under this circumstances the interaction among humans, microbes and climate needs careful consideration since they can significantly worsen climate change and seriously hinder ongoing and planned efforts to minimize climate-related crop production constraints.

For many gases microbes are major sources or sinks, as is indicated by the relative importance of different contributors (numbers in parentheses). Contributions from humans include direct inputs and removal (e.g., fossil fuel combustion, ammonia production from nitrogen), but also involve processes that significantly affect microbial inputs and removal (e.g., waste treatment and agriculture).

However, there was a limitation to explore the characteristics of methane producing and consuming microbes and how does microbial diversity affect its emission in the rhizosphere, a large fraction of atmospheric methane originates in or near roots of aquatic plants, including rice.

From previously investigated role of microbes for enhancing better crop production.

In soils, CH<sub>4</sub> can be oxidized into other forms of carbon via soil microbial activity through utilization of microorganisms, called *methanotrophs*. *Methanotrophs* are a group of bacteria that utilize CH<sub>4</sub> as its sole carbon and energy source in the presence of O<sub>2</sub>. It has been estimated that anywhere from 10 to 100 % of the CH<sub>4</sub> generated in landfills is oxidized by these bacteria (Bogner, J. *et al.*, 1995). Microbes play beneficial role in favoring the morphological, agronomic yield and nutritional quality improvement of many crops as presented on the table below.

Table 1:- The beneficial aspects of agriculturally important micro organisms on certain plant species.

*AIMs	Target plant	Beneficial effects	References
<i>Azospirillum spp.</i>	<i>Cynara</i>	Known to increase radical and shoot length, shoot weight	Jahanian et al., (2012)
<i>Psuedomonas spp.</i>	<i>Vigna radiata</i>	help to increase plant dry weight, root nodules, total chlorophyll content, seed yield and seed protein	Ahemad and Khan, 2011a
<i>Bradyrhizobium Spp.</i>	<i>Vigna radiata</i>	It increases the growth parameters at tested concentration of various herbicides.	Ahemad and Khan, 2011a
<i>Psuedomonas spp.</i>	<i>Brassica juncea</i>	provides ability in biomass increase	Ma <i>et al.</i> (2011)
<i>Rhizobium</i>	<i>Pisum sativum</i>	Is known to increase the symbiotic properties of plants like nodulation and leghemoglobin content, enhancement of nitrogen and phosphorous uptake, seed yield and seed protein.	Ahemad and Khan, 2009; 2010; 2011a
<i>Bacillus weihensthansensis</i>	<i>Helianthus annus</i>	It can increase plant biomass and accumulation of trace elements like Cu, Ni and Zn in the roots and shoot systems along with their mobilizing potential.	Rajkumar <i>et al.</i> (2008)
<i>Bascillus spp</i>	<i>Oryzae sativa</i>	It can promote the root and shoot growth	Beneduzi <i>et al.</i> (2008)

\*AIMs=Agriculturally Important Microbes

The Earth is a closed system where it produces everything it needs to ensure the survival and growth of its residents. In this closed system *Bacteria* and *archaea* are involved in the 'cycles' of all the essential elements. In the carbon cycle methanogenes convert carbon dioxide to methane through methanogenesis and in the nitrogen cycle nitrogen fixing bacteria convert nitrogen in the atmosphere to be used by plants to build its protein (Dariel Burdass, 2008). Single celled cyanobacteria called *Prochlorococcus* and *Synechococcus* remove about 10 billion tons of carbon from the air each year; this is about two-thirds of the total carbon fixation that occurs in the oceans. With this fact scientists hope to understand microbes ultimately being able to slow down increases in levels of carbon dioxide and other greenhouse gases and eventually reduce global climate change so as the crop productivity declination can be easily mitigated.

### 3.2. Biological control for weeds, Pest and plant diseases

Change in climate not only affects the potential crop yield but it may also modify the activities of pests and pathogens. If climatic change causes a gradual shift of agricultural regions, crops and their associated pests, diseases, and weeds may migrate together (Bhattacharyya *et al.*, 2016). Increasing atmospheric carbon dioxide (CO<sub>2</sub>) reduces crop nitrogen content (Niklaus *et al.*, 2007), which may retard many pests and diseases and thereby causes change in the composition of weed flora that accompanies the crops.

Bio controlling microorganisms have demographic characteristics related to those of their "host" populations: They depend on the density reached by populations of the target organism (insect, disease, weeds). Competition, predation and parasitism by these natural enemies are the principal biotic factors that control the stability of pest and disease populations by exerting a crucial influence on their development. Entomologists make particular use of the diversity of predators and parasites as biocontrol agents (insects and mites) (Bhattacharyya *et al.*, 2016). Pesticide consumption in the globe was a very huge. In 1990s, the figure stood in India at about 80,000 tonnes per year. Unfortunately, this was still inadequate to protect the farmer's interests and it led to a backlash of another kind.

The World Health Organization (WHO) recently recorded that chlorinated pesticides like DOT and benzene hexachloride (BHC) were increasingly being used in the globe. Therefore, food commodities, such as wheat, rice, and pulses, showed high residual contents. During the last decade, the daily intake of DOT was 0.27 mg per person and the level of accumulated DOT in the body was 12.8 - 31 parts per million (ppm) (Ben Romdhane *et al.*, 2008). Therefore it is mandatory to think other controlling measure for pest and diseases and the formulation by using bio control agents will the most promising.

Viruses, bacteria and fungi can function as bio control agents against insect pests. Many of these microorganisms have a narrow host range. This means that they are 'choosy' or selective about the insect species they attack. Therefore, they do not randomly destroy beneficial or non-target insects. The foremost attempt is to improve the speed of kill by genetic engineering. Employing virus to deliver harmful proteinaceous toxin into the larvae of pests could greatly increase the efficiency of kill. The possible candidate examples for genetic engineering are caterpillar-specific toxin, and neuro hormones. This genetically engineered virus would now produce the toxin along with the other proteins that it naturally makes. So once inside the insect host, the virus would not only overwhelm its system but also destroy it with the toxin. Of course, precautionary measures should be taken to make the engineered virus "safe". That is to say steps are taken to ensure that the engineered virus does



not run wild in the ecosystem or attack unintended targets.

The most popular bacterial pesticide is BT, a mixture of *Bacillus thuringiensis* spores and its toxin. As a pesticide, *B. thuringiensis* accounts for over 90 per cent of the total share of today's bio insecticide market (Ben Romdhane *et al.*, 2008). Thus the strain, *B. thuringiensis* variety. *israelensis* was of immediate practical importance. Now the insecticidal preparations of this strain are being used all over the world for pest control. Apart from virus and bacteria, fungi also affect insects. Many insects have fungi in their guts, use fungi as food or are attacked by fungal pathogens. Over 400 different species of fungi have been shown to parasitize living insects. The host range varies with the fungus species concerned. For example, *M. anisopliae* can parasitize as many as 200 different insects. An interesting use of *M. anisopliae* has been discovered by scientists. Termites are notorious pests. In order to ensure the specific mode of action of the mass produced natural enemies used in biological control, the so-called specialist species are generally preferred to general species. This is why predators are used less frequently than parasitoids, for instance, even if there are exceptions to the rule such as ladybirds (predators, but most of the species only eat aphids) and *Phytoseiulus persimilis* (Bhattacharyya *et al.*, 2016).

Not only an entomologists, Plant pathologists also work on competitor micro-organisms that prevent infection by and proliferation of phytopathogenic species (e.g. yeasts colonising the surface of apples intended for storage, which prevent the formation of *Penicillium expansum*). However Fungi too often play havoc with crop plants, scientists have developed a policy in which they use fungus to battle another. It is almost like setting a thief to catch a thief and it is one of the most promising ways to control plant pathogenic fungi. Around 50 different fungal genera cause plant infections. A number of saprophytic fungi produce antibiotics, enzymes and toxins to fight the pathogens. However, these products are known to be useful in eradicating pathogens, very few are registered as commercial agents. Therefore, efforts largely empirical were made to identify selective biocontrol agents. As an example *Trichoderma harzianum* is a potential biocontrol agent for a number of soil borne plant pathogens.

All plants normally exude a carbon-rich liquid that feeds the microbes (Farrar *et al.*, 2014). Plants also exude various chemicals in response to a range of biotic and abiotic stressors, including insect attacks, and water stress. Weed scientists are interested in biocontrol agents that are specific in action and protect the crop from any unintentional effects: phytophagous (plant-eating) insects, pathogens and even herbivorous fish have been used to limit the development of water hyacinth, which has invaded numerous stretches of water in Africa. Soil bacteria sense these chemical-based messages and secrete chemicals of their own that can activate complex plant defenses in the plant (Glick, 2012).

Microbial biopesticides are the best modern tools in agriculture (Bhardwaj *et al.*, 2014). These microorganisms enhance plant growth by controlling phyto pathogenic agents through a wide variety of mechanisms such as production of antibiotics, siderophores, HCN, production of hydrolytic enzymes, acquired and induced systemic resistance (Somers *et al.*, 2004; Chandler *et al.*, 2008). The most popular biological control application for weed management includes *Trichogramma* spp. parasitoid is used in weed management. Native microorganisms are usually exploited to develop biofertilizer and bio pesticide to assist plant growth promotion as well pest and disease control.

### 3.3. Role of microbes in sustainable soil fertility improvement

Biological control is the use of beneficial natural enemies to reduce the numbers of pathogenics and the addition of symbiotic organisms to ensure beneficial cooperation with the host. Rhizosphere and endosphere are the two important regions where optimum colonization of microbials reported (Berg *et al.*, 2014). Microbial biofertilizers are the substances that contain live microorganisms which, applied on the seed, plant surface or soil, colonize the rhizosphere, and promote plant growth through increased supply of primary nutrients for the host (Bhattacharyya and Jha, 2012; Vessey, 2003). Positive effects of inoculants on the soil microbial biomass may be short-lived (Kim *et al.*, 1997b), and increases in biomass or activity can even be due to the indigenous population feeding on the newly added microorganism (Bashan 1999). The most successful and widely studied inoculants are the diazotroph bacteria (*Rhizobium*, *Bradyrhizobium*, *Sinorhizobium*, *Frankia*) used for symbiotic fixation of N<sub>2</sub> from air. *Rhizobia* are known for their ability to establish symbiotic interactions (Shridhar, 2012; Wang and Martinez-Romero, 2012) with leguminous plants by the formation and colonization of root nodules, where the bacteria can fix nitrogen to ammonia and make it available for the plant. Addition of efficient *Rhizobium* strains in soil is in practice in many crops, since they can improve soil fertility and help in plant growth by improving nutrient availability. Each year, about 175 million ton of N is contributed by BNF globally (Burns and Hardy, 1975), of which nearly 79% is accounted for by terrestrial fixation. Therefore, symbiotic nitrogen fixation is of great importance not only in the production of leguminous crops but also in the global nitrogen cycle (Ben Romdhane *et al.*, 2008). *Rhizobium* biofertilizer in legumes are reported for their ability to replace chemical nitrogen up to 30- 35% when they are applied along with the chemical fertilizers in field (Mia *et al.*, 2010). Likewise, *Acetobacter*, *Allorhizobium*, *Aspergillus*, *Azorhizobium*, *Azospirillum*, *Azotobacter*, *Bacillus*, *Bradyrhizobium*, *Mesorhizobium*, *Penicillium*, *Pseudomonas*, *Rhizobium*, etc., have established their efficacy as potent plant growth promoters (Vessey, 2003).

Provided soil conditions are favourable for rhizobia survival (Slattery *et al.* 2001), inoculation can increase microbial C and N in the rhizosphere compared with uninoculated soils (Beigh *et al.* 1998; Moharram *et al.* 1999). However, scientific preparation and application of microbial formulation is important while developing the agriculture in a sustainable way.

Population changes can be limited to the season of inoculation, if the newly added organism is not as well adapted to the soil conditions as the indigenous population (McInnes and Haq 2003).

Mycorrhizal fungi and PGP bacteria are the other biological products capable of modulating the physiological responses (Vacheron *et al.*, 2013) and thereby helps to increase plant tolerance to survive under adverse environmental conditions. *In vitro* as well as pot experiments confirmed the potentiality of rhizosphere and endosphere bacteria in improving the plant growth and tolerance during stress. The plant growth of microbial inoculated plants increased up to 40% suggesting the potentiality of PGP microbes in agriculture (Perez-Montano *et al.*, 2014).

#### 4. CONCLUSION

Agriculture is expected to pay a significant cost of the damage caused by climate change which is commonly expressed as a flood, warmest temperature, wind storm and erratic rainfall in our universe. According to the Intergovernmental Panel on Climate Change (IPCC) 2007 report, Africa will be the most vulnerable to climate change globally, due to the multiple stresses of poor infrastructure, poverty, and governance. Due to this temperatures are likely to increased by between 1.5-4°C in this century. Projections on yield reduction show a drop of up to 50% and crop revenue is forecast to fall by as much as 90% by 2100 since the changes favors soil fertility declination, weed, insect and crop pest spread. For this humans are responsible for substantially accelerating present day changes. These changes may adversely affect human health and the biosphere on which we depend. As an option many interventions are being implemented to alleviate these constraints from these the most dominants are temporarily improvement of crop productivity through inorganic fertilizer application, chemical pesticide application for weed, disease and insect controls. In fact these measures were effective for currently achieved better production however the future fate of meta and micro climates were highly suppressed. Therefore, replacement of each measure with biological controls will enable to address both productivity and sustainability issues.

To these end the article highlighted potential measures for climate change threats. From these the development of several agriculturally beneficial microbes for certain plants saving 10 billion tons of carbon from the air each year, popular bacterial pesticide that constitute over 90 per cent of the total share of today's bio insecticide market, a potential bio control agent called *Trichoderma harzianum* for controlling a number of soil borne plant pathogens and the diazotroph bacteria (*Rhizobium Bradyrhizobium*, *Sinorhizobium*, *Frankia*) used for symbiotic fixation of N<sub>2</sub> from air and plant growth promotion role for better soil fertility improvement were addressed in this article.

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