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Climate Change and Measures to Mitigate its Effects in Crop Production: Review Paper

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Abstract

Agriculture is extremely vulnerable to climate change. Rising atmospheric concentration of carbon dioxide, increasing average temperature, change in rainfall amount and patterns and extreme events are the major factors which pose negative impact on crop production. Climate change also affects the availability of water resources and the distribution of agricultural pests and diseases. The emission of atmospheric greenhouse gases such as carbon dioxide, methane, nitrous oxide, water vapor etc. from industries and agricultural sector are contributing to the global warming. For example, higher temperatures eventually reduce yields of desirable crops while encouraging weed and pest proliferation. Changes in precipitation patterns also increase the likelihood of short-run crop failures and long-run production declines. Therefore, effective mitigation measures such as carbon sequestration and on-farm reduction of greenhouse gas emissions are very crucial to minimize the negative impacts of climate changes on crop production in future.

Key words: Climate change, Global warming, Greenhouse gas, Mitigation

1. Introduction

Climate change is one of the major factors which severely affect production and productivity of crops. Rising atmospheric concentration of carbon dioxide, increasing average temperature, rising in sea water level, change in rainfall amount and patterns and extreme events are the major factors which pose negative impact on crop production. Climate change also affects the availability of water resources and the distribution of agricultural pests and diseases. The emission of atmospheric greenhouse gases such as carbon dioxide (CO_2), methaneCH_4), nitrous oxide (N_2O), water vapor etc. from industries and agricultural sector are contributing to the global warming.

Due to fossil fuel combustion and land use changes, 40% of CO_2, 259% of CH_4 and up to 120% of N_2O released globally through human sources (Hutchinson *et al.*, 2007).Since the industrial revolution, the concentration of CO_2in the atmosphere has risen from about 270 parts per million to about 370 parts per million (IPCC, 2007).The concentration of CO_2 is projected to potentially rise to 550 parts per million by 2100 under the IPCC scenario under the lowest future emissions and greater than 800 parts per million under the business as usual scenario (Schmidhuber and Tubiello, 2007). Atmospheric CH_4 concentration has increased from about 700 to 1745 parts per billion by volume over the same period and is increasing at the rate of 7 parts per billion by volume per year. Similarly, the atmospheric concentration of N_2O has increased from about 270 parts per billion by volume to 314 parts per billion by volume and increasing at the rate of 0.8 parts per billion by volume per year (Searchinger *et al.*, 2008).

Long term effect of climate change may also result in decreasing water supplies, accelerating land degradation, and decreasing crop yields worldwide as well as most African smallholder farmers where rain fed agriculture is the common practice (World Bank, 2003). Extreme weather events are expected to rise, especially droughts and flooding that can completely destroy farmers' crops and livelihoods. Sixty five percent of African countries have reported weather-related crises, such as severe droughts, within the past ten years (EM-DAT, 2013). Overall effects on cropping systems and farm activities will vary regionally. Importantly, they will also depend on the specific management systems in use and their adaptive capacities. Climate change is also responsible for shifts in the beginning, end and length of growing seasons, and for poor distribution of within-season rainfall.

Crop productivity and soil water balance have been studied with crop growth models by using parameters from different climate models. Mean while, climate variability is one of the most significant factors influencing year to year crop production, even in high yield and high-technology agricultural areas. In recent years, more and more attention has been paid to the risks associated with climate change, which will increase uncertainty with respect to food production (Reddy and Pachepsky, 2000).

Global food security, threatened by climate change is one of the most important challenges in the 21st century to supply sufficient food for the increasing population while sustaining the already stressed environment (Lal R., 2005). Water availability will be one of the limiting constraints for crop production and food security. Fujihara *et al.* (2008) pointed out that water scarcity will not occur if water demand does not increase; however, if the irrigated area is expanded under present irrigation efficiency rates, water scarcity will occur. Climate change has already caused significant impacts on water resources, food security, hydropower, human health especially for African countries, as well as to the whole world (Magadza, 2000).

Developing countries and their economic progress are likely to suffer tremendously from climate change, given their extremely nature-dependent agrarian economies (Mendelsohn and Dinar, 2009). As a result, accurate quantification of the impact of climate change on the agricultural sector is of paramount importance in guiding appropriate adaptation measures (Stage, 2010).

Ethiopia is one of the most vulnerable countries to climate variability. The agriculture sector which contributes more than 45% of GDP, 80% to labor force and 85% to foreign exchange earnings is highly susceptible to climate change (MoFED, 2006), it included that more than 95% of crop production which is rainfall dependent has been produced by smallholders and subsistent farmers who have less capacity to adaptation of climate change. Climate change affects the production and productivity of the crop sector by decreasing soil fertility, increasing crop susceptibility to pests and crop diseases and frequent drought and floods due to low irrigation scheme, poverty, high population pressure, lack of institutional capacity to adaptation (Mahmud *et al*., 2008).Therefore, this review is aimed at addressing the impacts of climate change on crop production in order to develop possible mitigation and adaptation strategies.

2. The effect of climate change on agriculture

Agricultural sector is extremely vulnerable to climate change. For example, rising atmospheric CO_2 concentration, higher temperature, changing patterns of precipitation, and altered frequencies of extreme events will have significant effects on crop production, with associated consequences for water resources and pest/disease distributions. Climate change is already affecting African agriculture in general and Ethiopian in particular. Global average temperatures have risen by 0.85^0C and this is reflected across all regions of Sub-Saharan Africa since 1886 until 2012 and expected to increase by 1.5^0C by 2050 (AGRA, 2014).

The negative effects of climate change have adversely affected the agricultural sector, perhaps more than any other sector that contributes to human livelihoods. In sub-Saharan Africa, where most soils are depleted of nutrients, droughts, flash floods, and the increased temperatures associated with climate change have reduced the productivity of arable lands, consequently leading to severe food insecurity relative to an ever-increasing population (Vanlauwe *et al*., 2010). The gaps between actual and potential yields in most African countries are wider than in Latin America and Asia, and resource-poor smallholder farmers in sub-Saharan Africa are highly vulnerable to the effects of climate change (AGRA, 2014).

Climate change poses significant risks to smallholder farmers in Africa, especially brings changes in precipitation (both its quantity and distribution) and the higher evapo-transpiration rates predicted by climate models, will impact agriculture worldwide. As compared to commercial counterparts, smallholder farmers are more directly dependent on ecosystem services and have less capacity to adapt to changing climate (IFAD, 2013) though they are not the largest contributors to climate change, they are likely to be among those who bear the brunt of climate change impacts (AGRA, 2014).

2.1. Rising atmospheric concentrations of carbon dioxide

The increasing concentration of CO_2 to the optimum level is very important to crop production. It acts as a fertilizer which enhances growth and development as well as stimulates photosynthesis and improves water-use efficiency (Bazzaz and Sombroek, 1996).Many experiments showed that crop yields increase on average by approximately 30% for a doubling of CO_2 concentration (Hsiao and Jackson 1999). Importantly, crop responses to elevated CO_2 have been shown to be modulated by environmental and management factors. For instance, relative crop yield response to elevated CO_2, compared to ambient CO_2 levels, is greater in rain-fed than in irrigated crops, due to a combination of increased water-use efficiency and root water-up take capacity (Tubiello and Ewert, 2002). Even though, the increasing atmospheric $CO_2$to the optimal level is contributing to increasing crop yields by enhancing the rate of photosynthesis, it is also a major cause of the greenhouse gas effect which affects soil and water quality, weed-crop competition, weed and pest interactions which directly or indirectly pose adverse effects on crop production.

2.2. Average temperature increase

Temperature is one of the climate variability that affects crop production. There are a forecast that countries in the low latitude such as tropical and subtropical regions where water availability is low would be generally be at risk of decreased crop yield at even 1 to 2^0C of warming (Parry *et al*., 2007). This is due to increased evapo-transpiration and lower soil moisture levels. As indicated by Peng *et al*. (2004), from analyzed data (1979–2002)in the Philippines, rice grain yields have declined by about 15% for each 1^0C increase in growing-season mean temperature. Temperature trends in Australia were responsible for 30–50% of observed recent gains in wheat yields, with increases in minimum temperatures and a related decrease in frost frequency which was the dominant influence (Nicholls, 1997).Chmielewski *et al*. (2004), found that in Germany, for the period 1961–1990, the beginning of the growing season advanced by 2.3 days per decade, following increases in mean annual air temperature of 0.36^{0}C per decade.

The impacts of climate change on soil fertility is also need attention as the soil physical, chemical and biological properties are very important for crop production. For instance, increased temperatures will accelerate the rate of soil organic matter decomposition, with negative effects on soil water-holding capacity and nutrient loss, more rapid. Organic matter decomposition will inevitably reduce the potential of innovations that seek to increase carbon sequestration in the soil (Paustian, 2009). Furthermore, projected increases of rainfall amounts and intensity will lead to greater erosion of nutrient-rich topsoil and more intense leaching of plant-available nutrients beyond the root zones of crops(AGRA, 2014).The global surface temperature increased by 0.6^{0}C since the late 19thcentury with a current average warming rate of 0.17^{0}Cper decade (IPCC, 2001). Such temperature increase would considerably resulted in 0.5-1% of precipitation increase per decade in the most of Northern Hemisphere and 0.3% increase in the tropics and sub-tropics (Lal, 2004). Consequently, land productivity, biomass accumulation, biodiversity, and the whole environmental system would be negatively affected.

According to UNDP (2008), Ethiopian annual temperature has rapidly increased in the last five decades. The mean annual temperature rose by 1.3^{o}C or by 0.28^{o}C per decade during 1960-2006. The frequencies of hot days and nights have also showed an increasing trend during these years. While the average number of 'cold days' has decreased by 5.8% from 1960-2003, the average number of 'cold' nights per years has decreased by 11.2%. In the coming 100 years, the average temperature in Ethiopia has projected to increase from 23.08^{o}C during 1961-1990 to 26.92^{o}C in 2070-2099 (World Bank, 2008). Significant temperature difference is there among different parts of the country; highlands in the Central North of the country will be as cold as -0.5^{o}C, the South East low lands will be as warms as 37^{o}C. These extreme temperatures constrain crop production by limiting water availability and growth of many plants (Temesgen *et al*., 2008).

2.3. Change in climate variability and extreme events

Climate change may be characterized by an increase in climate variability (IPCC, 2001a). This may heighten the risks of crop failures, often connected to specific extreme events during critical crop phases, such as heat waves or late frosts during flowering. In addition, increases in temperature and precipitation variability will put pressure on crops grown on their marginal climate ranges.

Precipitation extremes such as droughts and/or floods are also detrimental to crop productivity. Heavy precipitation and flooding regimes could increase crop damage in some areas, due to water-logging, physical plant damage and pest infestation (Rosenzweig *et al*., 2002a). At the opposite extreme, greater drought frequency and increased evaporative demands may increase the need for irrigation in specific regions, further straining competition for water with other sectors (Rosenzweig *et al*., 2004).

2.4. Change in rainfall amount and patterns

Plants and animals fundamentally rely on adequate fresh water, and agricultural water accounts for 70% of water use world-wide. Water shortages caused by global warming will be the greatest problem for crop production. As temperatures increased evaporation from the earth's surface and from plants increased and arid regions will become further desertified. Particularly in semi-arid regions, increase in temperature along with reduced precipitation will likely result in the loss of arable land in the region due to decreased soil moisture, increased aridity, increased salinity and groundwater depletion (Parry *et al*., 2007). This condition could result in famines and mass migration of the societies living in the areas.

The intensity of rainstorms could increase in some areas and precipitation could become more variable and unpredictable (FAO, 2008). The change in rainfall can affect soil erosion rates and soil moisture, both of which are important for crop yields. Water shortages could lead to water rationing and higher water costs and will limit opportunities to maintain or extend these cultivated agricultural lands through the use of irrigation; reduction in available good quality water for crop at certain times of the year will negatively affected food supplies (FAO, 2008). In countries which rely on rain-fed agriculture like Ethiopia, distortion of the rain fall pattern would limit crop production and this would bring untold physical and socio-economic suffering to the rural farmers as it occurs sometimes.

Regarding the precipitation, there is inter-annual and inter-decadal rainfall variability in Ethiopia. Therefore, rainfall variability is the major source of risk for farmers who depend on crop production. There are two important rains in Ethiopia- the 'Kiremt' and 'belge'. The Kiremt rain, which constitutes the majority of the crop production usually begin in March and/or May in South West and advancing northwards affecting most of the country from July through September(CSA, 2011). Historically the country has been prone to extreme weather variability, which is the cause for major droughts that led to dreadful famines and floods struck different parts of the country (World Bank, 2006).The drought and devastating floods that have been occurring in some parts of Ethiopia is one of the indications of the effects.

2.5. The impacts of climate change on weeds, insects and diseases

To achieve high yields, crops must be protected from pests: insects, diseases, and weeds. Of the total cropping area worldwide, crop yield is decreased by 10–20% by weeds (Mirabelli *et al*., 2005). Many C4 weeds are found in arable C3 crops and many C3 weeds in arable C4 crops. Therefore, under high temperatures and increased atmospheric CO_2 concentrations, weed damage to arable C4 crops in tropical and subtropical semiarid areas is predicted to increase. Higher temperatures may increase the growth of some weed species and extend their geographic range towards higher latitudes (Dahlsten and Garcia, 1989). In addition, warmer temperatures may speed development rates of some insect species; resulting in shortened times between generations and improved capacity for over-wintering at northern latitudes.

Current crop-pest interactions may change in response to elevated CO_2. For instance, due to differential responses of weeds and crops to CO_2, some C3 weeds may become more invasive (Patterson, 1993). Elevated CO_2 may also indirectly modify insect-crop relations, via an increase in the C:N ratio in crop leaves, which renders them less nutritious per unit mass. This would stimulate increased feeding by insects, leading to more plant damage (Salt *et al*., 1995).Temperature raise also will expand the range of many agricultural pests and diseases by increasing the ability of pest population to survive and attack crops there by cause yield reduction.

3. Climate Change Mitigation Measures

The mitigation of anticipated negative impacts of climate change on crop production is worldwide concern in future to overcome the increasing demands for food as global population continues to rise from 6 billion people today to an anticipated 9 billion by 2050 (UN-DESA, 2004). It is clear that overall crop production will need to continue to increase by 50% over the next few decades to meet this anticipated demand, although predicting future global food production is complex. This brings further concerns that, if the rising demand for food is met through current technologies and cropping practices, further environmental degradation is inevitable (Bruinsma, 2003).

While agriculture stands to be greatly affected by projected climate change, it also and has been historically, a major source of greenhouse gases to the atmosphere, thus itself contributing to climate change, possibly even from its inception. In intensive agricultural systems with crops and livestock production, direct and indirect CO_2 emissions are predominantly connected to field crop production and are typically in the range of 150–200 kg Carbon per hectare per year (West and Marland, 2002). Livestock production has an environmental cost contributing to climate change by emitting greenhouse gases, either directly by enteric fermentation or indirectly by feed-production activities, deforestation, overgrazing, etc. (Dourmad *et al*., 2008).

Greenhouse gas emissions can emanate from all the main steps of the livestock production cycle. At the farm level, CH_4 and N_2O are emitted from enteric fermentation and manure. In ruminant species, CH_4 is exhaled as a byproduct of the process of fermentation of fibrous feedstuffs in the rumen. N_2O is released from manure during storage and spreading, and CH_4 is also generated when manure is stored in anaerobic and warm conditions (Hichem *et al*., 2011), and indirectly through the destruction of biodiversity, the degradation of land, and water and air pollution. Recent full greenhouse gases analyses of different farm systems in Europe showed that such CO_2emissions represent only 10–15% of the farm total, with CH_4 contributing 25–30% andN_2O, by far the largest emitter, contributing roughly 60% of total greenhouse gases emissions from farm activities (Flessa *et al*., 2002).

3.1. Carbon Sequestration

The management of agricultural carbon cycle plays a crucial role for the mitigation of greenhouse gas accumulation in the atmosphere. To this end, possible mitigation approaches in agriculture concentrate on either or both of two key components such as sequestration of atmospheric carbon in agricultural soils, resulting in increased soil organic carbon pools and reduction of greenhouse gas emissions to the atmosphere from agricultural operations. An important difference among the two options above is that soil carbon sequestration is ultimately finite (Lal *et al*., 1999); positive manipulations in soil management will tend to increase the equilibrium soil carbon pool by increasing carbon inputs into the soil or by slowing decay rates of soil organic matter, but soil organic carbon accumulation will not proceed above the resulting new storage point. By contrast, management changes that reduce carbon fluxes from agricultural operations can last indefinitely, as long as the new management system is sustainable in both energy and ecological terms (Schlesinger, 1999).

In order to assess fully the net carbon effects of a mitigation practice, it is necessary to analyze the full carbon cycle of a given agricultural system. For example, West and Marland (2002), analyzed the full carbon cycle for intensive agriculture in the US Midwest(corn, wheat, and soybean rotation systems) and found that reduced-tillage was superior to conventional tillage, not only in terms of its direct benefits (carbon stored in soil of 330 kg carbon per hectare per year compared to zero in conventional tillage), but also in terms of indirect effects, resulting in reduced carbon emissions;137 kg carbon per hectare per year in reduced tillage versus 178 carbon per hectare per year in conventional tillage.

3.1.1. Restoration of Degraded Soil

Restoring degraded soils and ecosystems has a high potential for sequestrating soil carbon hence most degraded soils have lost a large fraction of the antecedent soil organic carbon pool, which can be restored through adopting sensible land use practices. Potthoff *et al.* (2005), indicated that the CO_2 emissions ranged from 1.2 to 2.5 kg carbon per hectare per hour from the soil surface in the tilled plot without vegetation.

Converting degraded soils under agriculture and other land uses into forests and perennial land use can enhance the soil organic carbon pool. For instance, on a vertisols in Ethiopia, Lulu and Insam (2000), observed positive effects of alley cropping (agro-forestry) with Sesbania on the soil organic carbon pool. Establishing new forests, grass or perennial shrubs including perennial bio-fuel crops if they can grow successfully on land of limited agricultural value is an obvious option for implementing a policy of soil carbon sequestration, but with minimal impact on food production, and avoiding indirect land-use change (Preger *et al*., 2010). For instance, as the soil organic carbon content had become very small after the long period of degradation, it is likely that the scheme will lead to significant sequestration of carbon with minimal loss of food production and consequently minimal pressure for indirect land-use change elsewhere (Powlson *et al*., 2011).

3.1.2. Changing arable land to grassland or forest

The arable soils usually have a much smaller soil organic carbon content than the equivalent soil under forest or grass, this change in land use will almost always lead to an accumulation of soil organic carbon. Poulton *et al.* (2003) reported that an increase in soil organic carbon in topsoil of approximately18 tonesha^{-1} over a 35 years period when arable land in the same region is sown to permanent grass. Johnston *et al.* (2009) also reported that soil organic carbon is increasing after conversion from arable cropping to permanent grass, and reaching a maximum after about 150 years in the temperate climate. These carbon accumulations in soil plus vegetation after land-use change from arable to forest, grassland or perennial crops results from photosynthesis by the newly established vegetation.

A part of the new photosynthate is transferred to soil through roots and leaf-fall; some of this is rapidly decomposed and returned to the atmosphere as CO_2 but a fraction is stabilized in soil and becomes a component of soil organic matter (Powlson *et al*., 2011).Consequently, removing land from arable agriculture and conversion to perennial plants such as trees, grass or shrubs can be regarded as a positive contribution to sequestration of carbon. Even though, soil organic carbon sequestration following land use change is likely to be beneficial for climate change, some caveats and complications must be considered in addition to the general limitations.

The first event is, the change in land use from agriculture will almost certainly alter the fluxes of other greenhouse gases. Many measurements showed that soil disturbance reduces methane oxidation rates in aerobic soils by about 80%, so an eventual fivefold increase in CH_4oxidation rates can be expected under woodland when the soil has stabilized (Powlson *et al*., 2011).In many cases decreased emissions of N_2O would also be expected in view of the cessation of N fertilizer or manure inputs that would accompany removal of land from agriculture, but exceptions to this generalization have been observed. In regions of the world where deposition of reactive N compounds is substantial, the N input to semi-natural forest or grassland may exceed N uptake by plants and lead to an N surplus, which, in turn may result in increased N_2O emission (Dalal and Allen, 2008). Goulding *et al.* (1998), reported that N_2O emission rates of up to 1.6 kg N_2O per hectare per year from small areas of woodland, approximately equal to the emission from the arable land receiving 288 kg nitrogen per hectare per year. However; Dalal and Allen (2008), concluded that tropical forests could provide a large carbon sink, but in many cases the overall contribution to climate change mitigation is negligible because of N_2O emissions, possibly connected with rapid nitrogen mineralization rather than nitrogen deposition.

3.1.3. Additions of organic materials to soils

Additions of any organic matter is an excellent means of improving soil physical, chemical and biological conditions and is almost always desirable (Johnston *et al*., 2009). Whether or not increases in soil organic carbon resulting from organic additions constitute mitigation of climate change depends on the alternative fate of the material. Addition of cereal straw to soil usually leads to an increase in soil organic carbon content, though this may be slow and not measurable for some years and the magnitude of the increase depends on the quantity and type of straw returned and the soil type and climate (Preger *et al*., 2010). Addition of organic matter to soil genuinely represents additional retention of carbon in soil, although much of the organic carbon added in straw will decompose and be returned to the atmosphere as CO_2, a fraction will be retained in soil (Powlson *et al*., 2011).

The addition of nutritive amendments can increase plant biomass production and crop residue inputs to the soil, thereby increasing soil organic matter and soil carbon contents. In a comparison of fertilized and non-fertilized soils, Gregorich *et al.* (1994) observed that the soil organic matter accounted for a significant part of the gain in total soil carbon and that the gain was attributed to residue additions.

3.1.4. Cropping system

The great potential of carbon sequestration in cropland has provided a promising approach to reducing the atmospheric concentration of CO_2 for mitigating climate change. However, this approach depends on cropping systems, which may be defined as an operating system for growers to follow in their practices for crop production. An ideal cropping system for carbon sequestration should produce and remain the abundant quantity of biomass or organic carbon in the soil.

The organic carbon concentration in the surface soil (0-15 cm) largely depends on the total input of crop residues remaining on the surface or incorporated into the soil. Cleaning up the crop top from the soil decreases soil carbon greatly (Kuo and Jellum, 2002).Biomass accumulation can be enhanced by an increase in cultivation intensity, growing cover crops between main crop growing seasons, reducing fallow period of land, crop rotations, and intercropping systems (Qingren, 2010). Biomass return to the soil can be improved by elimination of summer or winter fallow, and maintaining a dense vegetation cover on the soil surface, which can also prevent soil from erosion for soil organic carbon loss.

Crop rotation can improve biomass production and soil C sequestration, especially rotations with legumes and non-legumes. Growing legumes can substantially reduce the nitrogen input as chemical fertilizers, which in turn can reduce the fossil fuel consumption in manufacturing fertilizers (Zentner *et al*., 2004). Increase in cropping intensity or cropping more frequently by reducing the frequency of bare land fallow in the crop rotation is another effective approach to improve biomass production and soil carbon sequestration. In addition, increase cropping intensity can decrease organic matter decomposition rate and mineralization or oxidation of soil organic carbon.

Mixed cropping is additional effective approach in the intercropping system to optimize the ecosystem for maximum plant production. The benefits of mixed cropping are to balance the input and output of soil nutrients, suppress weeds and insects, control plant disease, resist climate extremes, such as wet, dry, hot and cold, and to increase the overall productivity with limited resources (Hirst, 2009). For example, corn, beans and pumpkin are grown together without significantly affecting the growth of one another. The corn provides a stalk for the beans to climb on, the beans are nutrient-rich to offset what taken up by corn, and the pumpkin grows low to the ground to keep weeds down and to prevent water from evaporation. With these mutual benefits, an overall optimal productivity with corresponding quantity of biomass of both underground and aboveground can be reached, which shows a potential for biomass return and soil carbon sequestration (Qingren, 2010).

Growing cover crops is another effective approach to improve carbon sequestration and soil organic carbon storage, by covering the bare lands during the offseason. It can be used to maintain soil organic matter and increase the potential for carbon sequestration (Clark, 2007), provided a source of carbon that helped to function in the capture and re-release of nitrogen fertilizer when was needed most. This method transforms inorganic nitrogen fertilizer into a slow-release fertilizer. A study found that excessive nitrogen applied to a growing corn crop, planting a cereal rye cover crop in late fall after crop harvest effectively temporarily captured and immobilized in the spring, dramatically reducing N_2O losses to background levels (Steinke and Snapp, 2013)

3.1.5. Biochar application

The biochar is used to describe a wide range of materials produced from the thermal treatment of organic matter usually plant material but sometimes municipal waste or animal manure under reduced or zero oxygen. Studies have shown that cover crops, mulches, compost, or manure can be effective in enhancing soil organic carbon pool and agricultural productivity in the tropics (Banger *et al*., 2010).The benefits of such amendments are, however, often short lived, especially in the tropics, since decomposition rates are high, and the added organic matter are usually mineralized to CO_2within only a few cropping seasons. Organic amendments therefore have to be applied intermittently to sustain soil productivity (Wolde and Noble, 2013).In case of agricultural lands converted to no-tillage systems, stored carbon can be released once it is converted no-tillage back to conventional tillage. Therefore, carbon sequestered by these crop and soil management practices is generally considered only temporarily sequestered from the atmosphere and associated with a high risk of rapid or large scale leakage (Lehmann, 2007).

Management of black carbon may overcome some of those limitations and provide an additional soil management option, once it is incorporated into soil difficult to imagine any incident or change in practice that would cause a sudden loss of stored carbon indicating that biochar is a lower-risk strategy than other sequestration options. Thus, biochar could be a potentially a powerful tool for mitigating anthropogenic climate change as the carbon in biochar, is claimed to resists degradation and can sequester carbon in soils for hundreds to thousands of years (Bracmort, 2010).

3.1.6. Nutrient management

Soil organic matter is the major soil component that stores and releases CO_2. There is confounding evidence about the role that applying additional nitrogen can play in sequestration and emission of carbon from soil organic matter. Khan *et al.* (2007), reported that fertilizer nitrogen promoted the decomposition of crop residue and soil organic matter, and hence the release of CO_2. However, Grove *et al.* (2009), found no evidence that fertilizer nitrogen led to the loss of soil organic matter. Increasing nitrogen application rate had no significant effect on soil organic carbon in the top two feet of the soil, although the higher nitrogen application rates produced greater yield and biomass (Steve, 2013).

Careful nutrient management is crucial to soil organic carbon sequestration hence the use of organic manures and compost enhances the soil organic carbon pool more than application of the same amount of nutrients as inorganic fertilizers. The fertilizer effects on soil organic carbon pool are related to the amount of biomass carbon produced or returned to the soil and its humification. Adequate supply of nitrogen and other essential nutrients in soil can enhance biomass production under elevated CO_2 concentration (Gregorich *et al.*, 2001). Nitrogen fertilizers increase ammonia concentrations, causing release of more NO and N_2O in the process of oxidizing ammonium ions. Since NO is necessary for this reaction to occur, its increased emissions cause the cycle to repeat, thereby further contributing to NO and N_2O concentrations in the atmosphere (Willey *et al.*, 2009); this contributes to greenhouse gas emission.

4. Conclusions

Crop production is highly affected by climate change worldwide. However, the situation is more severe in the developing countries where the majority of the population is dependent on weather linked agricultural system. As climate changes due to rising concentrations of greenhouse gas in the atmosphere, agriculture is one of the key human activities affected. Projections show that while overall global food production in the coming decades may keep pace with the food requirements of a growing world population, climate change might worsen existing regional disparities because it will reduce crop yields mostly in lands located at lower latitudes where many developing countries are situated.

The major contributing factors that pose challenges on crop production and result in yield reduction are increasing average temperature, increasing concentration of $CO_{2,}$ fluctuation in rainfall patterns and distributions as well as change in the crop-pest interactions due to climate changes. Hence, proper mitigation measures such as carbon sequestration and on-farm reduction of greenhouse gas emissions are better practiced to minimize the negative impacts of climate changes.

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