ATMOSPHERIC CARBON AND FOOD SECURITY IN NEPAL

Krishna B. Karki (PhD)[13]

ABSTRACT

Release of carbon from soil system is inevitable. It is increased through emission breath by animals, burning of fossils fuel, biomass burning and intensive agriculture. The only question is how to absorb that carbon in the atmosphere and reduce the carbon content of the atmosphere. Increase of CO_2 in atmosphere increases the crop yield due to high photosynthesis, but the crops should tolerate increased temperature caused by higher CO_2 concentration. Increase of soil organic matter through the addition of organic manure is one of the options that the carbon is retained temporarily, but in the long run because of oxidation and reduction process in soil, carbon will ultimately release to the atmosphere. Absorption of CO_2 by the plants is one of the options, which is known as sequestration to mitigate increased carbon in the atmosphere.

Key words: climate change, carbon sequestration, CO_2 in atmosphere and crop yield

INTRODUCTION

Increase of carbon-dioxide affecting greenhouse gas emissions and global warming has been a major concern on earth. Since atmospheric carbon is increasing every year from the last century which coincides with the start of industrial era. Increase of global population, demanding higher amount of natural resources for food, shelter and clothing has made the situation worst. Increasing demand of everincreasing population has affected forest cover. Every year 1.7% of forest cover is denudated in Nepal to meet the fuel wood demand and crop production pushing agriculture to marginal areas. This marginalization in one hand is not increasing crop production per unit area on the other the carbon stock that was stored in forest soil is released to the atmosphere and evolved as carbon dioxide gas. That ultimately increases concentration of GHGs and global warming potential (Knuston and Tuela, 2004).

Global temperature is found increased by 0.64o c over a century. This trend is increasing by every decade. Increase in global temperature is known as global warming and has caused disaster by melting polar ice, which helped rising sea water level. This seawater rise will put the coastal cities under water. Bangladesh and Maldives are especially affected. Nepal is also seriously affected in South Asia. Monsoon rainfall is also behaving differently. Some times heavy rain and other times drought. This erratic behavior of rain causing flood and drought has affected cropping season seriously affecting crop yield. Rise in temperature has melted glacier ice from the Himalayan Mountain faster. Glacier lake outburst in another threat to Nepalese people living downstream of such lakes. If this trend continues all the ice from the Himalaya will melt and there will be no more ice left to feed glacier fed rivers of Nepal.

OBJECTIVES

This article is presented with an objective of making public as well as government authorities aware on effect of carbon dioxide on crop yield.

[13] Chief, Soil Science Division, NARC. Phone: + 977 1 5521149 Email: ssd@narc.gov.np

METHODOLOGY

In the present context of climate change, its effect on agriculture is a concern of every agriculturists and planners in the country. Information is collected from the published and unpublished sources that are available in the country and websites. Experimental results from SSD/ NARC are also included.

FUNCTION OF CO_2 IN PLANT PHYSIOLOGY

The direct effects of increased carbon dioxide (CO_2) on plant growth refers to plant adaptation with the levels of temperature, precipitation, evaporation and growing season at their present values. The indirect effects include the results of any changes in the other variables, which affect plant growth that come as a result of the effect of increased CO_2 on global climate.

Life is base upon chemical reactions; many chemical reactions; but the chains of chemical reactions known as photosynthesis are the basis in one way or another of all life. Photosynthesis involves the input of carbon dioxide and water with radiant energy and the presence of a catalyst called chlorophyll. The outputs are carbohydrates, and Glucose reacts with oxygen in the following redox reaction. Carbon dioxide and water are waste products and the chemical reaction ($C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O$) is exothermic.

The catalyst for the reaction, chlorophyll, is an organo-metallic compound containing magnesium. It is one of the three organo-metallic compounds, which are the basis for life. The other two are the vital elements of the blood of mammals, hemoglobin, and of crustaceans and hemocyanin. Just as chlorophyll contains magnesium, hemoglobin contains iron and hemocyanin contains copper.

The process of photosynthesis is very complex, and chemists could find little about the processes until radioactive isotopes became available. First, the radioactive isotope of oxygen (^{18}O) was used to create water (H_2O). When plants were exposed to this radioactive water, the radioactivity showed up in the oxygen exhaled from the plants. This showed that the oxygen created by plants comes from the water it uses rather than from the CO_2. The oxygen in the CO_2 is incorporated in the carbohydrates created by the plants. Second, a radioactive isotope of carbon (^{14}C) was used to create carbon dioxide. Plants were exposed to this radioactive CO_2 for a few seconds and then the leaf material was chemically analyzed. In most plants, the radioactive carbon showed in a compound called phosphoglyceric acid (PGA). The molecule of this compound contains three carbon atoms and one atom of phosphorus.

Most plants, including trees and flowering plants, produce PGA as the first step in photosynthesis. A few plant species including tropical grasses such as sugarcane and maize produce malic or aspartic acid as the first step. The molecules of these compounds contain four carbon atoms and one nitrogen atom, similar molecular structure only the difference is addition of C and N. Because the initial products of photosynthesis for plants in this category involve compounds containing four carbon atoms, this class is called C_4. The other category of plants produces PGA, which contains three carbon atoms, so it is called C_3. This classification is important because the responses of the two categories of plants to increased CO_2 are different.

The direct effect of an increase in CO_2 over the years there have been numerous laboratory experiments, which conclude that increased levels of CO_2 result in increased plant growth; no matter how that plant growth is quantified. The effects of an enriched atmospheric CO_2 on crop productivity in large measures as positive, leaving little doubt as the benefits for global food security. Now, after more than a century, and with the confirmation of thousands of scientific reports, CO_2 gives the most remarkable response of all nutrients in plant bulk, is usually in short supply, and is nearly always limiting for photosynthesis. The rising level of atmospheric CO_2 is a universally free premium, gaining in magnitude with time, on which we can all reckon for the foreseeable future.

About 95 percent of all plants on the earth are of type C_3. C_4 crops constitute only 1. Among others the C_4 crops includes sugarcane, corn, sorghum and millet that are economically significant. The other 4 percent of plants are not economically significant. They include desert plants such as cactus. Quantification of the enhanced growth due to higher levels of CO_2 has been given by table 1.

Table 1: Increased growth resulting from a 100% increase in CO_2 level

Plant type	Proportional increase
C_3	41%
C_4	22%

Source: Witter. 1995

THE EFFECT OF TEMPERATURE ON PLANT RESPONSE TO HIGHER LEVELS OF CO_2

Photosynthesis consists of chemical reactions. Chemical reactions proceed at a higher rate at higher temperatures. The rule of thumb is that there is a doubling of the reaction rate for every 10°F rise in temperature. Plants grow faster at a higher temperature providing they have adequate levels of CO_2, water, sunlight and plant nutrients. The C_4 plants have a great response rate for a higher temperature than does the C_3 plants.

A higher temperature without adequate level of the necessary ingredients for growth might produce no response or even damage. Under most circumstances, the availability of CO_2 is the factor, which limits growth. Thus with a higher level of CO_2 in the air plants can grow faster with a reasonable higher temperature i.e. >40oC.

Higher concentration of CO_2 increases temperature. Plants transpire water vapor to keep an even temperature. Plant transpiring more water increases humidity in the vicinity of plant leaves reducing plant water through transpiration. This situation helps leaves control stomata opening limiting transpiration thereby absorb more CO_2 (Witter, 1992). That means plants need less water. This statement is confirmed by experiment in USA. The experimenter further found that enhanced CO_2 increased growth by 31 percent in plants with adequate moisture but it increase growth by 62 percent for plants in moisture-stressed condition. In effect, enhanced CO_2 by reducing water loss created the same effect as providing more water. Thus the effect in moisture-stressed plants was the effects of enhanced CO_2 plus the effect of increased water. The evidence that clinches the argument is that some greenhouse owner artificially elevates the CO_2 level to triple what the level in the atmosphere is (US National Assessment Synthesis Team 2000). The effect of increased CO_2 in narrowing the stomata of plants has the additional benefit that a lesser amount of pollutants in the air will make it through the narrower stomata openings. Thus enhanced CO_2 has the effect of protecting plants against damage from air pollutants such as ozone or sulfur dioxide. The effect of enhanced CO_2 is even greater for plants grown under low light conditions. The enhance growth is greater than 100 percent for a 100 percent increase in CO_2. This compares to less than 50 percent for plants grown in normal light conditions (Poerter, 1993).

IMPACT OF INCREASED TEMPERATURE ON HUMAN HEALTH

There is a close link between local climate and the occurrence or severity of some diseases and other threats to human health. Extreme temperatures can directly cause the loss of life. Moreover, several serious diseases appear only in warm areas. Finally, warm temperatures can increase air and water pollution, which in turn harm human health. Extremely hot temperatures increase the number of people who die on a given day for many reasons: People with heart problems are vulnerable because their cardiovascular system must work harder to keep the body cool during hot weather. Heat exhaustion and some respiratory problems increase. Higher air temperatures also increase the concentration of ozone at ground level. The natural layer of ozone in the upper atmosphere blocks harmful ultraviolet radiation from reaching the earth's surface; but in the lower atmosphere, ozone is a harmful pollutant. Ozone damages lung tissue, and causes particular problems for people with asthma and other lung diseases. Even modest exposure to ozone can cause healthy individuals to experience chest pains, nausea, and pulmonary congestion. In much of the US, a warming of four degrees (F) could increase ozone concentrations by about 5 percent.

Statistics on mortality and hospital admissions show that death rates increase during extremely hot days, particularly among very old and very young people living in cities. We have hearing news that in the Terai of Nepal numbers of people are killed by heat waves. Same examples can be cited from India. Extensive analyses have been done of potential mortality risks in the US and China from heat stress in a greenhouse enhanced world, and these indicate that thousands of lives may be at risk in each country.

Global warming may also increase the risk of some infectious diseases, particularly those diseases that appear only in warm areas. Deadly diseases often associated with hot weather, like the West Nile virus, Cholera and Lyme disease, spread rapidly because increased temperatures allow disease carriers like mosquitoes, ticks, and mice to thrive. Some scientists believe that algal blooms could occur more frequently as temperatures warm--particularly in areas with polluted waters - in which case diseases such a cholera that tend to accompany algal blooms could become more frequent (US EPA). Malaria, too, is rare in the United States even in warmer regions where the mosquito that transmits the disease is found, because this nation has the ability to rapidly identify and contain outbreaks when they appear. However, a 2005 study by the World Health Organization indicated that global climate change is directly tied to increased rates of malaria, malnutrition, and diarrhea. It estimated that climate change contributes to 150,000 deaths and 5 million illnesses each year in developing countries where medical facilities are limiting.

Industrialized countries are equally vulnerable to the infestation of diseases. There can be a significant indirect adverse health effect of climate change for richer countries may be the surge of migrants from poorer countries across borders as a result of catastrophic climatic events such as droughts, floods or severe storms. A pulse of sudden migration of desperate people may bring diseases that could overwhelm public health resources of the nations where they flee. There could also be substantial outlays to counter pandemic diseases and deficits of food, water and energy, together with the additional social strife and political turmoil these would entrain.

GLOBAL WARMING AND FOOD SECURITY

It seems obvious that any significant change in climate on a global scale should impact local agriculture and thereby affect the world's food supply. Considerable study has gone into the questions of how farming might be affected in different regions, and by how much; and whether the net result may be harmful or beneficial, and to whom. Some of the major organizations studying the effect of climate change on agriculture are; FAO, Columbia Center for International Earth Science Information Network (CIESIN) and The Intergovernmental Panel on Climate Change (IPCC)

IMPACTS OF CLIMATE CHANGE ON FOOD SECURITY

How will climate change alter the ability of the world's growing population to gain access to food? By integrating agricultural and socio-economic models, we can begin to predict if there will be an increase in hunger and famine as a result of global warming. Food security has been defined as "access by all people at all times to enough food for an active, healthy life". The World Food Summit, convened in 1996 and in 2002 by the Food and Agricultural Organization of the United Nations (FAO) in Rome, highlighted the basic right of all people to an adequate diet and need for concerted action among all countries to achieve this goal in a sustainable manner. How vulnerable households, regions and countries are to climate change's impacts on agriculture will depend on their access to land, water, and government support and action.

The World Food Trade Model, designated as the Basic Linked System (BLS), links countries through trade, world market prices, and financial power. The BLS estimates that in 1980, there were about 500 million people at risk of hunger in the developing world (excluding China). Without climate change, the number of people expected to be at risk of hunger in 2060 has been estimated at ~640 million. However, with unmitigated climate change, declines in yields in low-latitude regions (where many developing countries are located) are projected require to imports large amount of cereals. Higher grain prices will affect the more number of people at risk of hunger. The number of hungry people in developing countries will increase by ~1% for every 2-2.5% increase in prices. This means the number of people at risk of hunger grows by 10-60% in the scenarios tested, resulting an estimated increase of 60 to 350 million people in this condition (Rosenzweig and Parry, 1994).

MITIGATION AND ADAPTATION MEASURES

Reducing carbon emissions

One of the ways to prevent the effects of global warming is to decrease the amount of carbon dioxide and other greenhouse gases into the atmosphere. The Kyoto Protocol is a document that came out of the UN sponsored Earth Summit in Rio de Janeiro in 1992. This agreement, which has been ratified by over 100 countries, seeks to limit the amount of CO_2 emitted into the atmosphere to 1990 levels. However, the United States, which emits 25% of all global greenhouse gases, has not yet ratified the Kyoto Protocol.

Adaptation to global warming

Even if all CO_2 emissions stopped at this moment, the amount of CO_2 already emitted into the atmosphere will result in an enhanced greenhouse effect for the next 50 years. Thus, people will need to adapt to the effects of climate change. Adaptation can be defined as "any action that seeks to reduce the negative effects, or to capitalize on the positive effects, of climate change" (Riebsame et al., 1995). Adaptive actions may be either anticipatory or reactive in nature. An example of an anticipatory adjustment is the development of heat- and drought-tolerant crop varieties. The levels of adaptation undertaken by a region may have significant effects on how climate change will affect agriculture in that area. Rosenzweig and Parry (1994) grouped into two levels of adaptation.

The Level 1 adaptations include:

- shifts in planting date (±1 month) that do not imply major changes in crop calendar,
- additional application of irrigation water to crops already under irrigation,
- changes in crop variety to currently available varieties more adapted to the altered climate.

Level 2 adaptations imply more substantial change to agricultural systems, possibly requiring resources beyond the farmers' means, including:

- investment in regional and national agricultural infrastructure with especial focus on agricultural research
- policy changes at the regional and national level

Adaptation, especially Level 2, may significantly reduce the effect of climate change on agriculture and hence the number of people at risk of hunger. However, adaptation in developing countries, although it reduces the negative effect of global warming, does not completely eliminate the potential increase in hunger.

CROP ADAPTATION IN CONTEXT TO CLIMATE CHANGE

Atmospheric Research results on climate change indicates that the amount of global warming that the Protocol would prevent in the next fifty years would be 0.07°C (0.13°F). This amount of temperature reduction is too small an amount to measure with any confidence (Friedlingstein et al., 2006).

Increasing temperature results more evaporation from the earth surface and water bodies. More and more water will evaporate and water bodies will dry up limiting drinking and irrigation. It has foreseen that there will be acute shortage of water, and there will be hue and cry in the developing countries. Ground water is pumped out and most of the wells have gone dry. Bhairawa Lumbini Ground Water Project is one of the burning examples in Nepal. Despite awareness of serious problem faced by the world, Government of Nepal is not doing much about it. More and more research is needed in this regards whereas the Govt. of Nepal has neglected agricultural research. If the government does not opens its eyes there is going to be acute famine in the country, which will be too late to save millions of Nepal people from hunger. Even if we shall have enough money to buy food, the world will deny selling food.

Soil quality and soil carbon storage that occur during production of crops biomass crops needs to be quantified. Experimental results that production of biomass may yield soil carbon increase provided the crop residues are incorporated into the soil. Incorporation even woody biomass of corn has increased 1.3 Mg ha-1 year-1 of which 79% was stumps and large roots and 21% fine 'roots. Most of the carbon storage occurred mainly in the upper 30 cm although coarse roots were found to depths of greater than 60 cm. Biomass crops contributed to improvements in soil physical quality as well as increasing belowground carbon sequestration. The distribution and extent of carbon sequestration depends on the growth characteristics and age of the individual biomass crop species. Time and increasing crop maturity will determine the potential of these biomass crops to significantly contribute to the overall national goal of increasing carbon sequestration and reducing greenhouse gas emissions thereby reduce global warming.

The potential of no-tillage (NT) soils for increasing the soil organic carbon (SOC) pool must be critically and objectively assessed. Most of the previous studies about SOC accrual in NT soils have primarily focused on the surface layer (<20-cm soil depth), and not for the whole soil profile. The lack of adequate data on the SOC profile is a hindrance to conclusively ascertain the effects of NT farming on SOC sequestration and off setting CO_2 emissions.

Our research suggests that farmers can make decisions about tillage that can help mitigate the effects of global warming. Switching from a conventional till method to conservation tillage could produce 15% more food on the same amount of land (SSD, 2007). This has serious implications, as the global population continues to rise and the need to feed more people using less land is becoming more urgent." For example, the conservation technique would use 52% less land than the organic method to produce the same amount of crop.

Action of government to mitigate climate change

Climate change over the next century may have significant effects on food supply, i.e., how much food is produced, as well as food security, i.e. how much food is available to people. How much, where, and when food supply and security will be affected by climate change are questions many international scientists and policy-makers are examining.

Over the past fifty years, technological advances in agriculture that have dramatically increased crop yields. However, despite these improvements, agriculture is still highly dependent on climate since solar radiation, temperature, and precipitation are the main drivers of crop growth. Since the industrial revolution, humans have been changing the global climate by emitting high amounts of greenhouse gases into the atmosphere, potentially resulting in higher global temperatures, changed hydrological regimes, and increased climatic variability. Therefore, the government of Nepal should give priority to agricultural research and invest sufficient on it. Policy focusing food security and environmental degradation should be planned accordingly.

CARBON SEQUESTRATION

Carbon dioxide increase in the atmosphere has become unavoidable because it has been a natural process. Depletion of soil organic carbon from cultivated land during intercultural operation cannot be avoided. Changes in land use also releases soil carbon depletion. Burning of fuel wood, cow dung, bush fires of tropical forest and fossil fuel combustion adds more carbon dioxide. Industries have worsened the problem. Once it is emitted, there are ways to absorb the atmospheric CO_2. This reduces the concentration of CO_2 to some extent. Trapping atmospheric carbon in soil by addition of compost and increase total soil carbon and absorption by forest growth is known as carbon sequestration. Sequestering can reduce and reduce concentration of atmospheric carbon in country level can trade carbon. Industrial nations pay for the carbon they have emitted to the nations, which have sequestered carbon. Nepal has won carbon trading prizes from World Bank and other industrialized nations as a result of mass a forestation installation over 200,000 biogas plants in the country is a significant achievement for Nepal. Therefore, the government should focus on more plantations, reduce fossils fuels, reduce fuel wood use, and pay more attention to use of renewable energy such as solar, wind, and hydropower and biogas to limit carbon dioxide emissions to the atmosphere.

CONCLUSION

In conclusion, global warming may result in detrimental effects on food security, especially in developing countries. The scientists are painfully aware that despite investment in modern production technology such as improved seeds, mineral and organic fertilizers, increase irrigation facilities and trained technical manpower food production in totality remained unchanged. Since last few years, food deficiency has been increasing. We have the challenge that productivity in rainfed farming is declining. Though we have attained yield increase of cereals yields of legumes, oilseeds and forage crops has not increased. Food security includes not only food availability but also nutritional security and environmental safety. To achieve food security in context to increased carbon in the atmosphere Political will is very necessary. Government should develop agricultural policy focusing judicious use of inputs (fertilizers, seeds, water, pesticides, energy and management) including pricing and marketing structures. Political commitment to investment enough in agricultural research and development is needed. Agricultural program should go together with renewable energy and stop food grain Unless timely attention in tackling the effect of global warming and climate change on crop production is paid this country is going to face acute shortage of food resulting wide famine in the near future.

REFERENCES

Friedlingstein, P., P.Cox, R.Betts, L.Bopp, W.von Bloh, V. Brovkin, P.Cadule, S.Doney, M.Eby, I.Fung, G.Bala, J.John, C.Jones, F.Joos, T.Kato, M.Kawamiya, W.Knorr, K.Lindsay, H.D. Mathews, T. Raddatz, P. Rayner, C.Reick, E.Roeckner, K.G. Schnitzler, R.Schnur, K. Strassmann, A.J.Weaver, C. Yoshikawa and N. Zeng, 2006. Climate, 19:3337-3353.

Knutson, T. R. and R. E. Tuleya, 2004. Impact of CO_2- Induced Warming on Simulated Hurricane Intensity and Precipitation: Sensitivity to the Choice of Climate Model and Convective Parameterization". Journal of Climate, 17(18):3477-3494.

Patrick J. M. and R. C. Balling, 2000. The Satanic Gases: Clearing the Air about Global Warming, Cato Institute, Washington, D.C.

Poorter H., 1993. Interspecific variation in the growth response to an elevated and ambient CO_2 concentration. In: Vegetation, pp77-97.

Riebsame, W.E., K.M. Strzepek, L.L. Wescoat Jr., R. Perritt, G.L. Gaile, J. Jacobs, R. Leichenko, C. Magadza, H. Phien, B.J. Urbiztondo, P. Restrepo, W.R. Rose, M. Saleh, L.H. Ti, C. Tucci and D. Yates, 1995. Complex river basins. As Climate Changes: International Impacts and Implications. In: Strzepek, K.M. and J.L. Smith (eds.). Cambridge University Press, Melbourne, Australia, pp57-91.

Rosenzweig, C. and M.L. Parry, 1994. Potential impact of climate change on world food supply. Nature, 367:133-138,

SSD, 2007. Soil Science Division, Khumaltar, NARC Kathmandu. Annual Report 2007, pp51

US-NAST, 2000. Climate Change Impacts on the United States - The Potential Consequences of Climate Variability and Change. Overview: Agriculture. US Climate Change Science Program/ US Global Change Research Program. www.climatescience.gov

Wittwer S H., 1995. Food, Climate and Carbon Dioxide. CRC Press, Boca Raton, Fla., pp337.