How Global Warming Could Benefit Agriculture

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Introduction

Global warming has profound effects on agriculture – both positive and negative ones. The key question is if the net overall effect will be beneficial or damaging to global agriculture. Crops need heat, water and carbon dioxide (CO2) to grow and produce high yields. Global warming is supposed to increase both temperature and rainfall while man-made CO2 emissions are increasing the CO2 concentration in the atmosphere. Provided that both the increases in heat and precipitation remain moderate, this would lead to a rise in crop yields, which in turn would increase global food supply. Not only would the warming improve yields from cold lands and rainfall yields from dry lands, but the increased CO2 concentrations in the atmosphere would enhance yields even more, especially in dry areas.[1] Even the Intergovernmental Panel on Climate Change (IPCC) admits that warming would have beneficial effects on agriculture. The IPCC's 2007 assessment report states that in temperate regions, moderate to medium increases in local mean temperature (1- 3 degrees Celsius), along with a CO2 increase and rainfall changes, will have beneficial impacts on crop yields.[2]

Warmer temperatures

Warmer temperatures would increase plant growth and yields for most crops. In the temperate climate zone, warmer conditions would speed the budburst in spring and delay the browning in autumn, which results in a significant increase in the duration of the growth season.[3] A study using 88 years of data (1900-1987) from 12 different locations within the eastern U.S. forest, which stretches from South Carolina to Vermont, showed that 1 degree Celsius increase in the mean annual air temperature increases the length of the growing season by approximately 5 days.[4] Longer growing seasons allow farmers to plant their crops earlier and harvest them later, which increases yields. Some farmers might even be able to have two harvests in one year, effectively doubling the yield.

Rising temperatures could make land which is now too cold to grow crops available for farming. Vast amounts of land in Canada, Russia and Argentina could become available for agriculture if temperatures rise. A study of long-term trends (1901-2002) in the climate of the province of Alberta in western Canada found that earlier last spring frosts, later first fall frosts, and longer frost-free periods can be detected all over the province. These changes in the climate extended the area suitable for corn planting by about 200-300 kilometres to the north when compared with the 1913-32 area. Farming in Alberta has benefited from

1 Ridley, Matt, "The Rational Optimist", Harper Collins Publishers, 2010, p. 337.

2 Seguin, B., "The consequences of global warming for agriculture and food production", *Animal Bytes,* June 2009, http://www.animalbytes.org/wp-content/uploads/2009/06/edition_2_lgccsequin.pdf

3 Seguin, op. cit.

4 Bast, Joseph, and Bast, Diane Carol (eds), "Climate Change Reconsidered: The 2009 Report for the Nongovernmental International Panel on Climate Change (NIPCC)", *The Heartland Institute*, 2009, p. 556, http://www.nipccreport.org/reports/2009/pdf/CCR2009Full-Report.pdf

the warming during the 20th century. Elsewhere, maize yields in Argentina increased by 18 percent between the periods 1950-70 and 1970-99 due to changes in the climate.[5] 30-50% of the substantial increase in wheat yields in Australia from 1952 to 1997 was due to the increases in minimum temperature.

Chinese scientists conducted field experiments from 2006 to 2008 in the semiarid northwest of China to evaluate the effects of warming on the productivity of winter wheat. It has been predicted that the average temperature in this region would be 2.2 degree Celsius higher in 2050 than it was in 2002. The observed results of the study showed that this increase in temperature – if it really takes place – would lead to a significant change in the growth stages and water use of winter wheat, which would likely increase crop yields by 2.6 percent in low altitudes and 6 percent in high altitudes. Even without the benefits of the aerial fertilisation effect and the anti-transpiration effect of the continuing rise of atmospheric CO2, which will be discussed below, the increase of temperature that is predicted by 2050 would likely lead to increases in winter wheat production in the north-western part of China.[6]

More rainfall

Global warming would increase global precipitation because warmer air has more capacity to hold moisture than colder air. Rising temperatures are likely to accelerate evaporation rates worldwide. Warmer air over the oceans evaporates more water, which leads to the creation of more and thicker clouds and more rainfall. Water tends to cycle through the atmosphere very quickly; the atmosphere has the shortest residence time of any major component of the water cycle. Thus more evaporation would likely to lead to more rainfall in a globally averaged sense. Increased rainfall would help crops to grow quicker and increase yields and reduce the need for irrigation.

Warmer and wetter conditions in large parts of the United States have helped farmers grow corn, soybeans and other crops in regions that only a few decades ago were too dry or too cold. Bruce Babcock, an Iowa State University agriculture economist, said that soybean production is expanding north and corn production north and west because of earlier planting dates and later freezes in the fall. Cotton production is expanding northwards too. The change is due partly to a 7 percent increase in average rainfall in the United States in the past 50 years.[7] In the Canadian province of Alberta, situated in the great plains, precipitation from May to August increased 14 percent from 1901 to 2002 and annual precipitation increased similarly with most of the increase coming in form of low-intensity rain, benefitting agriculture.[8]

The Sahara desert and the Sahel, a semiarid area just south of the Sahara, have been greening due to increasing rainfalls recently. Satellite photos, taken between 1982 and 2002, revealed extensive re-greening throughout the Sahel. Vegetation has greatly increased in

5 Bast, Joseph, and Bast, Diane Carol, op. cit. p. 366-367

6 *CO2 Science*, "The Effects of Warming on Winter Wheat Yields in Semi-Arid China", 10 November 2010, http://www.co2science.org/articles/V13/N45/B3.php

7 *USA Today*, "Warmer, wetter climate helping U.S. farmers grow more crops", 8 October 2010, http://www.usatoday.com/weather/climate/2010-10-08-climate-farmers_N.htm

8 Bast, Joseph, and Bast, Diane Carol, op. cit, p. 366-367

central Chad and western Sudan. If sustained, the increasing rains could revitalize drought-ravaged regions, reclaiming them for farming.[9] The United Nations' Africa Report of 2008 confirmed that the greening of the Sahel was now well established and that increases in rainfall are the main driver of the change in vegetation cover. The report noted that there was a 50% increase in vegetation in parts of Mali, Mauritania and Chad during 1982-2003.[10] The southern border of the Sahara has been retreating, making farming viable again in what were some of the most arid parts of Africa. There has been a spectacular regeneration of vegetation in northern Burkina Faso, which was devastated by drought and the advancing desert 20 years ago. It is now growing so much greener that families who fled to wetter coastal regions are starting to come back. There are now more trees, more grassland for livestock and a 70% increase in yields of local cereals such sorghum and millet in recent years. Vegetation has increased significantly in the past 15 years in southern Mauritania, northern Burkina Faso, north-western Niger, central Chad and much of Sudan. The increased vegetation will fix the soil, enhance its anti-wind-erosion ability, reduce the possibility of released dust and consequently cause a decline in the numbers of sand-dust storms.[11] In Burkina Faso and Mali, production of millet rose by 55 percent and 35 percent, respectively, since 1980.[12]

There is of course no guarantee that the increased precipitation would be distributed evenly worldwide. There could be regions where global warming would bring less, not more, rainfall, which would make farming more difficult.

Higher carbon dioxide concentration

The Fourth Assessment Report of the IPCC hardly mentioned the beneficial effects of the higher atmospheric CO2 concentration on crops although thousands of peer-reviewed papers, studies and experiments have proven these benefits. Higher concentrations of CO2 stimulate the productivity of plants. CO2 is the primary raw material utilized by plants to produce the organic matter out of which they construct their tissues. With more CO2 in the air, the productivity of nearly all crops rise, as they produce more branches and tillers, more and thicker leaves, more extensive root systems and more flowers and fruit.[13]

Many experiments have shown that plants benefit enormously in environments of higher concentrations of atmospheric CO2.[14] Photosynthesis is stimulated by elevated CO2 levels and might increase by about 10-20 percent with CO2 at 550 parts per million (ppm) for temperate crops such as wheat, rice or soybean and by up to 10 percent for tropical crops like maize or sorghum.[15] Wheat grows 15-40 percent faster if CO2 is at 660 ppm levels than at a 295 ppm level. CO2 levels in the atmosphere, currently at around 390 ppm, are expected to reach 750 ppm at the end of the 21st century. At this level photosynthesis of soybean

9 Owen, James, "Sahara Desert Greening Due to Climate Change?", *National Geographic*, 31 July 2009, http://news.nationalgeographic.com/news/2009/07/090731-green-sahara.html

10 Goklany, Indur, "Trapped Between the Falling Sky and the Rising Seas: The Imagined Terrors of the Impacts of Climate Change", *Social Science Research Network*, 2009, p. 30, http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1548711

11 Bast, Joseph, and Bast, Diane Carol, op. cit., p. 555-556

12 Ibid. p. 552

13 Ibid, p. 361-362

14 *World Climate Report*, "Global Warming and California Agriculture", 2 April 2007, http://www.worldclimatereport.com/index.php/2007/04/02/global-warming-and-california-agriculture

15 Seguin, op. cit.

will increase by about 50%. Farmers enrich CO2 to 1,000 ppm levels in glasshouses to enhance the growth of their crops.[16] The CO2 fertilisation effect might increase aggregate potential productivity in China (e.g. if the crop is grown everywhere in the country) by 6.5 percent for rice, 18.6 percent for corn, 22.9 percent for potatoes and 24.9 percent for winter wheat during the 21st century.[17]

As CO2 concentrations continue to rise, rice plants will likely experience greater photosynthetic rates, produce more biomass, be less affected by root parasites and better deal with environmental stresses, all of which should lead to greater grain yields.[18] Laboratory and field experiments have demonstrated a significant positive impact of elevated levels of CO2 on total biomass and grain production of sorghum, a semi-arid crop.[19] The optimum growth temperatures for several plants have been shown to rise substantially with increasing levels of atmospheric CO2. Most plants will increase their optimum growth temperature by approximately 5 degree Celsius for a 300 ppm increase in the air's CO2 concentration. Plant photosynthesis can be expected to rise with increases in CO2 levels and temperature.[20] As the CO2 content of the air rises, many crops will likely develop larger and more extensively branching root systems that may help them to better cope with periods of reduced soil moisture. For a 300 ppm increase in CO2 levels, the root biomass of wheat and rice increase by 70 percent at ample water and nitrogen supply, at 58 percent at low nitrogen and at 34 percent at low water supply.[21]

Another major advantage of rising CO2 levels is that plants exposed to it generally reduce their water loss by transpiration. Their water-use efficiency rises, increasing their ability to withstand droughts. Soybeans that are grown at 700 ppm CO2 displayed 10-25 percent reductions in total water loss. Spring wheat grown at 550 ppm CO2 showed a water-use efficiency increase of about one-third compared to wheat grown at 370 ppm CO2. When more CO2 is available, plants are able to use less water to maintain previous levels of photosynthesis. This more efficient use of water has been observed in experimental studies and allows plants to grow in drier conditions. It is likely that food production will increase on a worldwide basis, even in areas where agricultural productivity is severely restricted due to limited availability of soil moisture.[22] CO2 enrichment has also been shown to help to improve the negative effects of several environmental stresses on plant growth, including diseases, predation by insects, shade (caused by increased cloudiness), ozone, low temperatures, nitrogen deficiency and UV-B radiation.[23]

How warming could negatively affect agriculture

While temperature increases are in general favourable for plant growth in cold and temperate climates, they could be unfavourable in some areas of the tropics and subtropics. In its 2007 assessment, the IPCC stated that in low latitudes higher temperatures are likely to

16 Ridley, op. cit., p. 337.

17 *CO2 Science*, "Chinese Agriculture to the End of the 21st Century", 19 August 2009, http://www.co2science.org/articles/V12/N33/B3.php

18 Bast, Joseph, and Bast, Diane Carol, op. cit., p. 372

19 Ibid, p. 373

20 Ibid, p. 466

21 Ibid, p. 527

22 Ibid, p. 409-410

23 Ibid, p. 414

shorten growing seasons and harm crops. In low latitudes, especially in the seasonally dry tropics, even moderate increases (1-2 degrees Celsius) are likely to decrease yields for major cereals.[24] According to climate models, cold and temperate regions would see a much higher increase in temperatures than tropical and subtropical areas. If this is true remains to be seen – climate models have a bad track record when it comes to forecasting. David Lobell and Just Costa-Roberts, of Standford University, and Wolfram Schlenker, of Columbia, have estimated global changes in crop yields due to increases in temperatures. They used the temperatures and precipitation figures for the parts of the world where wheat, corn, rice and soya are grown. During the seasons in which these crops grow, the arable area had on average become significantly warmer between 1979 and 2008. The researchers claimed that wheat yields went down by 5.5 percent and maize yields by 3.8 percent compared what they would have been with no climatic changes. They said that soya yields showed no real net effect on a global scale. Warming brought a clear benefit for rice grown at higher latitudes and some losses in warmer places.[25]

Adaptation

Farmers who live in areas where global warming will bring adverse effects have to adapt to the changing conditions by, for example, switching to crops which are better suited to warmer or drier weather. However, not all farmers have the means to do this and farming might have to shift to areas with adequate rainfall for growing crops. Still, farmers have a good track record when it comes to adaptation. Despite many warnings of doom, yields of arable crops have grown remarkably in the past half-century. Adaptation is predicted to improve yields by 10-15 percent in a warming world. Successful adaptation will require not just more research into improved crop yields and tolerance of high temperature, but also research into new ways of managing pests, improving and conserving soil, cropping patterns and crop-management techniques that add resilience.[26] Crops can be genetically modified to grow better in hot and dry conditions than conventional crops. Efforts to engineer hardier, drought-resistant strains of corn have produced 25-30 percent higher yields for farmers in several arid and semi-arid countries. The India-based International Crops Research Institute for the Semi-Arid Tropics has modified the genes of dry land crops like pearl millet, sorghum, chickpea, pigeon pea and groundnut. Genetically modified pearl millet and sorghum varieties are capable of producing good yields in temperatures of 42 degrees Celsius. Short-duration groundnut varieties have good levels of drought tolerance. So do chickpea varieties that can cope with terminal drought and have high levels of heat tolerance.[27] Such research—and its application—will make it likely that enough food for 9-10 billion people can be grown in a warmer world.[28]

24 Seguin, op. cit.

25 *The Economist*, "Hindering harvest", 5 May 2011, http://www.economist.com/node/18648350/print

26 *The Economist*, "Facing the consequences: Adapting to Climate Change", 25 November 2010, http://www.economist.com/node/17572735

27 *The Hindu*, "New crop varieties for a changing climate", 8 December 2010, http://www.hindu.com/seta/2010/12/09/stories/2010120950241300.htm

28 *The Economist*, "Facing the consequences: Adapting to Climate Change", 25 November 2010, http://www.economist.com/node/17572735

Conclusion

Moderate warming, increasing rainfall and higher atmospheric CO2 levels will have overall beneficial effects on agriculture and food production. Farmers who adapt successfully to a warming world will take advantage of these benefits.

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