IT'S NOT ALL IN FOR THE GREENHOUSE EFFECT

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The effect of climate warming (greenhouse effect) will have significant effects on greenhouse production. Forewarned is forearmed.

Interactive Effects of CO_2 and Climate Variables on Plant Growth.

S.B. IDSO, U.S. Water Conservation Lab.

Increases in atmospheric CO_2 may impact plant growth both directly — by providing more of one of the primary raw materials required for photosynthesis — and indirectly — by possibly altering the climate. In addition, the simultaneous occurrence of these two phenomena may further influence their individual effects. In experiments conducted at Phoenix, AZ, for example, it has generally been observed that the positive growth-enhancing effects of atmospheric CO_2 enrichment become progressively greater as the total environmental potential for growth increases. More specifically, it has been observed that increases in solar radiation and air temperature significantly amplify the positive effects of atmospheric CO_2 enrichment on net photosynthesis and plant growth. In fact, for the 8°C rise in mean global air temperature predicted by current climate models to accompany the 300 to 600 ppm doubling of the Earth's atmospheric CO_2 content currently in progress, the mean 30% increase in plant productivity caused by the direct effects of atmospheric CO_2 under unchanging climatic conditions more than triples to fully double crop yields.

The CO_2/Trace Gas Greenhouse Effect: Greatly Overestimated?

S.B. IDSO, U.S. Water Conservation Lab.

The climate models which have predicted a mean global warming of 8°C (4°C due to CO_2 and 4°C due to other trace gases) by the time Earth's atmospheric CO_2 content has doubled from 300 to 600 ppm are but primitive representations of the real world's complex climate system, in that many well-known processes are poorly parameterized, while others are totally ignored. In addition, it is the height of folly to presume that we know all that we need to know about the system to confidently predict the consequences of subtle atmospheric compositional perturbations in the manner attempted by the models. As a result, we cannot allow ourselves to be misguided by the models' highly-publicized but unfounded predictions. Rather, we must look to nature herself for the answer to the question of CO_2-induced climatic change. And when we do, it becomes abundantly clear that the warming predicted by the climate models is fully an order of magnitude too large.

Greenhouse Gas Emissions Related to Agriculture and Land-Use Practices.

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The potential effects on agriculture of increasing trace gas concentrations and concomitant climate change are likely to be substantial. The EPA has organized 12 studies of potential impacts on U.S. agriculture using a common set of climate change scenarios derived from General Circulation Models. These studies consider impacts on crop production, pest-plant interactions, and water quality and demand, among other effects. Conversely, with cropland and pasture now covering more than 30% of Earth's land surface, agricultural activity is a significant factor in producing the observed increases in the greenhouse gases CO_2, CH_4, and N_2O. Land clearing for agriculture and other purposes is responsible for 10-30% of total net CO_2 emissions, the rest being due to fossil fuel combustion. Intentional burning of agricultural wastes, grasslands, and forest makes a significant contribution to global emissions of CH_4 and NO_2 as well as CO and NO_x. Methane emissions from anaerobic digestion in rice paddies and domestic animal rumens account for 30-50% of the global total. Nitrous oxide emissions induced by application of nitrogen fertilizers are highly uncertain, but appear to contribute on the order of 10% of total NO_2 emissions. A variety of assumptions concerning population growth, income, and agricultural practices have been used to construct scenarios of future emissions. These models suggest that agricultural emissions of greenhouse gases are likely to increase substantially in the future unless steps are taken to control them. The relative contribution of agricultural and non-agricultural sources of greenhouse gases is compared in each scenario and options for reducing agricultural sources are discussed. Investigating potential approaches to reducing these emissions presents a major challenge to the agricultural research community.

Implications of Increasing CO_2 and Climate Change for Agricultural Productivity and Water Resources.

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Increasing CO_2 by itself has a favourable effect on production of agricultural crops and grassland. By combining the figures for the present rate of increase of atmospheric CO_2 with some direct experimental evidence for CO_2 effects on crop growth, this production increase is expected to amount up to about 0.2% per year. This direct growth enhancement can occur at equal or even at slightly decreasing crop transpiration. For nutrient-limited situations the growth enhancement will be less or even be absent, but there will be a larger decrease in transpiration demand. In water-limited situations the direct CO_2 effect is unequivocally positive.

These direct CO_2 effects will partly, and in places even entirely, be offset by adverse effects connected with expected warming of the climate. River basin runoff, being an excess phenomenon, will be particularly sensitive.

These changes will exert their influence at such a slow rate that they will be hardly noticeable in comparison with changes in technology and in economy. Yet they may gradually affect the range of options available.

Projected Effects of Increasing CO_2 and Trace Gases on Climate.

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The atmospheric concentrations of carbon dioxide, methane, chlorofluorocarbons, and other gases capable of trapping terrestrial infrared radiation have risen markedly since preindustrial times. Theoretical and numerical analyses agree that these changes will cause a warming of the global average temperature by order of a few degrees by the end of the twenty-first century, with actual changes depending on rates of emissions, location, uncertainties in understanding of the climate system, and other factors. Changes in temperature and water availability seem likely to induce changes in agricultural and natural ecological systems, with the rate, pattern, and magnitude of the changes being the most important — but still uncertain — determinants.

Implications of Increasing CO_2 and Climatic Change for Plant Competition in Natural and Managed Ecosystems.

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Future increases in the CO_2 concentration of the earth's atmosphere will directly affect the physiological processes and growth of plants. Indirect climatic effects, including global warming and changes in precipitation patterns and the frequency of weather extremes, may have greater impact than the direct effects of CO_2 on physiological processes. CO_2 enrichment to as much as twice ambient levels generally increases plant growth, although the magnitude of growth stimulation varies greatly with species, photosynthetic pathway, growth stage, and water and nutrient status. In both natural and managed ecosystems, differential growth responses to both CO_2 concentration and climatic change will affect the relative competitive ability and fitness of plants in the future. The relative importance of various weed species in agroecosystems may change, but selection of adapted crop varieties and management methods may minimize negative impacts. In natural ecosystems, species extinctions probably will increase because migration and adaptation through natural selection may be inadequate to accommodate climatic changes. Weedy species with broad ecological amplitudes are likely to prosper at the expense of endemic species or those already in marginal habitats.

Potential Effects of Climate Change on Wheat and Corn Production in the Great Plains.

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CERES-Wheat and CERES-Maize crop growth models were run with climate change scenarios from global climate models applied to thirty years of observed data for 14 sites in the Great Plains. The crop models were modified to simulate the physiological effects of increased CO_2 on photosynthesis and transpiration. Separate and combined physiological and climatic effects of CO_2 were calculated. With climate change scenarios alone, modeled dryland wheat yields decrease 10-55%, while modeled dryland corn yields decrease from 5-90%. Irrigation water increases where predicted precipitation decreases. Substitution of wheat cultivars with lower vernalization requirements and lower photoperiod sensitivity overcomes yield decreases at some sites, but not in others. Combined physiological and climate effects of CO_2 increase the modeled yields of wheat and corn in some locations in some years. The more severe the climate change scenario, the less compensation physiological effects of CO_2 provide.

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