The Greening of Planet Earth–*Confirmed!* Video Series

CO_2-induced Plant Productivity and Yield Increases Transcript

Atmospheric carbon dioxide: you can't see, hear, smell or taste it. But it's there—all around us—and it's *crucial* for life.

Composed of one carbon and two oxygen atoms, this simple molecule serves as the primary raw material out of which plants construct their tissues, which in turn provide the materials out of which animals construct theirs. Knowledge of the key life giving and life sustaining role played by carbon dioxide, or CO_2, is so well established, in fact, that humans—and all the rest of the biosphere—are described in the most basic of terms as *carbon-based lifeforms*. We simply could not and would not exist without it.

Ironically, far too many demonize and falsely label this important atmospheric trace gas a pollutant. Nothing could be further from the truth. Instead of being shunned like the plague, the ongoing rise in CO_2 should be welcomed with open arms. Why? Because plants *love* CO_2. Far from being a pollutant, this colorless, odorless, tasteless and invisible gas is better than the best fertilizer ever invented. Essentially, it is the "food" that sustains all plants on the face of the earth. And the more of it they "eat" (or take in from the air), the bigger and better they grow.

This figure presents a visual demonstration of this truly amazing benefit, as observed for the common house plant known as Golden Pothos. Both plants in the figure were grown under identical conditions, with the exception of atmospheric CO_2 content. The plant on the left, which was grown at about ¼ the CO_2 concentration of that to which the plant on the right was exposed, is clearly deficient in the amount of leaf, stem and root biomass it was able to produce.

Similar results are seen in this illustration of pigeon pea, where the growth-enhancing effects of CO_2 fertilization are once again readily apparent in the plants' leaf, stem and root biomass.

Our organization, the *Center for the Study of Carbon Dioxide and Global Change*, has been studying the effects of atmospheric CO_2 on plants for decades now. On our website we maintain a Plant Growth database, where we have archived the results of literally thousands of laboratory and field CO_2 enrichment studies (freely accessible at www.co2science.org). Such data confirm beyond any doubt that rising atmospheric CO_2 is greatly enhancing the productivity of Earth's plants. A 300 ppm increase in the air's CO_2 content will raise the productivity of most herbaceous plants by about one-third and is generally manifested by an increase in the number of branches and tillers, more and thicker leaves, more extensive root systems, and more flowers and fruit.

On average, a 300 ppm increase in atmospheric CO_2 enrichment leads to yield increases of 15% for CAM crops, 49% for C_3 cereals, 20% for C_4 cereals, 24% for fruits and melons, 44% for legumes, 48% for roots and tubers and 37% for vegetables.

The growth response of woody plants to atmospheric CO_2 enrichment has also been extensively studied. Reviews of numerous individual woody plant experiments have revealed a mean growth enhancement on the order of 50% *or more* for an approximate doubling of the air's CO_2 content, which is about one and a half times as much as the response of non-woody herbaceous plants.

This next slide illustrates this phenomenon in pine trees grown in normal air and air enriched with an extra 150, 300 and 450 ppm of CO_2. Taken approximately three decades ago, the person in the figure is our organization's emeritus President, Dr. Sherwood Idso, who worked for many years at the U.S. Water Conservation Laboratory in Phoenix, AZ, demonstrating the beneficial effects of atmospheric CO_2 enrichment on plants.

In one of his more famous experiments, he grew sour orange trees in ambient and CO_2-enriched air in the Phoenix desert for nearly 19 years. In that study, which at the time was the longest such experiment ever to be conducted anywhere in the world, trees exposed to a CO_2 concentration 75% greater than normal annually produced 80% more biomass and 80% more fruit. And as icing on the cake, so to speak, the vitamin C concentration of the juice of the CO_2-enriched oranges was between 5 and 15% *greater* than that of the juice of the oranges produced on the trees growing in ambient air.

Although much less studied than terrestrial plants, many aquatic plants are also known to be responsive to atmospheric CO_2 enrichment, including unicellular phytoplankton and bottom-rooted macrophytes, for both freshwater and saltwater species. Hence, there is probably no category of photosynthesizing plant that does not respond in a positive manner to atmospheric CO_2 enrichment and that is not likely to be benefited by the ongoing rise in the air's CO_2 content.

Perhaps the obvious question to ask at this point is what do such growth-enhancing benefits of atmospheric CO_2 enrichment portend for the biosphere?

One answer is greater crop productivity, and many researchers have acknowledged the yield-enhancing benefits of the historical and still-ongoing rise in the air's CO_2 content on past, present and future crop yields. In this regard, studies have shown that the benefits of CO_2 on agriculture are so important that without them, world food supply will fall short of world food demand by mid-century.

Direct monetary benefits of atmospheric CO_2 enrichment on both historic and future global crop production have also been calculated. Over the 50-year time period from 1961-2011, such benefits amount to over $3.2 trillion. And projecting the monetary value of this positive externality forward in time reveals that it will bestow an additional $9.8 trillion on crop production by 2050. And, as amazing as this estimate sounds, it may very well be vastly *undervalued*.

Consider, for example, the fact that rice is the third most important global food crop, accounting for 9.4% of global food production. Based upon data presented in our *CO_2 Science* Plant Growth Database, the average growth response of rice to a 300-ppm increase in the air's CO_2 concentration is approximately 35%. However, a team of researchers who studied the growth responses of 16 different rice genotypes, reported CO_2-induced productivity increases in those genotypes that ranged from near zero to a whopping +263%. Therefore, if countries learned to identify which genotypes provided the largest yield increases per unit of CO_2 rise, and then grew those genotypes, it is quite possible that the world could collectively produce enough food to supply the needs of all of its inhabitants, staving off the crippling food shortages that are projected to result in just a few short decades from now in consequence of the planet's ever increasing human population. Unfortunately, research has progressed but little on this front because the far too many view CO_2 as a pollutant instead of a valuable aerial fertilizer. It's time to wake up and change that.

In conclusion, as we consider all the productivity-related benefits rising atmospheric CO_2 offers global agriculture, it should come as no surprise that the father of modern research in this area – Dr. Sylvan H. Wittwer – has stated that "it should be considered good fortune that we are living in a world of gradually increasing levels of atmospheric CO_2," and that "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 future."

Dr. Wittwer could not have been more correct or insightful. Atmospheric CO_2—it's necessary for life.