Chapter 42
Crop Responses to the Global Increase in Atmospheric Carbon Dioxide Concentration

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Around the world there have been numerous assessments—both academic and in private and public sector reports—of the impact of prospective anthropogenic climate change on agriculture and forestry. However, many of them either do not include consideration of the direct CO₂ effect on plants or discount it as unimportant. This is surprising for several reasons. One is that the first global change attribute to be observed was the increase in atmospheric [CO₂] which has now reached 360 µL L⁻¹ starting from about 290 µL L⁻¹ before industrialization. Secondly, the increase in atmospheric [CO₂] is the most certain and most exactly quantified aspect of the global change. It is increasing by 0.5% yr⁻¹. Thirdly, the [CO₂] increase precedes global warming both conceptually (the former being the principal cause of the latter), and in practice (there still being uncertainty whether the observed average global warming is due to the enhanced greenhouse effect). Finally CO₂ effects on vegetation have been reviewed over the last 30 yr, including some major reviews in the early 1980s (e.g., Baker & Lambert, 1980; Lemon, 1983; Kimball, 1983; Strain & Cure, 1985; Warrick & Gifford, 1986) before “greenhouse popularization” took off. More recently there has been a proliferation of such reviews. Therefore it is clear that in order to assess the agricultural impact of the temperature, rainfall and UV-B changes which are being predicted, it is necessary to do so in the context of the ever higher levels of atmospheric [CO₂] which will quantitatively alter crop responses to them.

and rainfall can be readily studied over wide areas, but CO₂ effects cannot. Most evidence must continue to come from various kinds of enclosed systems together with models that extrapolate to the field in the long term.

42-1 GROWTH RESPONSES TO CARBON DIOXIDE AND THE IMPORTANCE OF ACCLIMATION

Most, but not all, controlled environment studies at elevated CO₂ levels report increased growth and/or economic yield of C₃ species. In a compilation of literature observations on CO₂ enrichment effects, Kimball (1983) reported a wide range of growth and yield responses to a [CO₂] doubling, ranging from a few slightly negative to a few exceeding a yield doubling. More than 90% of the results were in the range of a 0 to 100% yield increase with a doubling of atmospheric [CO₂]. Later studies have given similar results, ranging from a yield doubling and about a 30% growth increase for CO₂ doubling.

This range of CO₂ effects on growth is similar to the range of short-term effects on C₃ leaf net photosynthesis and is also similar to the theoretical range of effects of the primary CO₂ fixation enzyme ribulose 1,5-bisphosphate carboxylase/oxygenase (Rubisco) as given by the equations (Sharkey, 1986) using values for the kinetic parameters of the enzyme.