Potential impact of global warming on citrus production in the Caribbean Area

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Although increasing CO_2 levels over the last 50 years and the potential effect of this of increasing near-surface air temperatures on earth are well documented, it is not as clear what the final magnitude of change will be nor the time scale over which most of the changes will occur. Both temperatures and rainfall are expected to change. Climate and global warming researchers do not believe that all areas will be warmer or dryer, but most discussions about the Southeastern USA and Caribbean suggest that this area will be warmer and dryer under global warming conditions. The purpose of this paper is to discuss the possible climate change scenarios and how they may affect future citrus production in the Caribbean region.

Part of the uncertainty about how much effect global warming may have comes from the fact that natural climate cycles occur at least at three or 4 levels. These are the long term changes, such as ice ages every 100,000 years, apparent 100 year cycles, 10 year cycles related to solar irradiance and then 3 to 7 year cycles related to El Niño Southern Oscillations (ENSO). In any given year, one or more of the short-term cycles may cause as much or more difference in our weather than can be expected from global warming. The larger concern is for the long term effects of global warming on top of whatever normal climate changes may occur. There is also the issue of whether human behavior

will change enough and fast enough to moderate the predicted continued elevation in CO_2 levels.

The current projections show that 2004 was 0. 2-4 ^{o}C higher than 50 years ago. A general projection now in vogue is that temperatures might increase about 2^{o}C over the near future. For agriculture in general and citrus specifically, potential climate changes could effect growth and production through at least 3 weather changes: temperature effects on flower bud induction and fruit development, drought and water availability effects on growth and possible increases in hurricanes impacting tree condition and crop load. Currently the Caribbean Basin has years with marginal winter temperatures for flower bud induction. If average temperatures were to increase 2^{o}C, then the average level of flower bud induction from low temperature induction would decrease and fewer years with adequate cool temperature accumulation for flower bud induction would occur. On the other hand, if higher temperatures were accompanied by less rainfall then drought induced flower bud formation would increase, but no meaningful scenario is available for how much winter drought stress might occur or if the drought periods would be at another period in the year.

Higher temperatures would also accelerate fruit development leading to earlier maturity, lower acidity levels and probably less sugar content when harvest is necessary because of low acid levels. This is similar to growing citrus in more tropical climates. For fresh and processed fruit marketing, production of highly colored fruit would be less likely and juice content would decline earlier in the season. Juice acidity decreases about 0.05 % per month for a 2^{o}C increase

in fall temperatures. This could result in 0.2 % less acidity over the last 4 months of maturation.

Long term reductions in rainfall could have positive or negative effects on citrus production. As mentioned, longer dry periods would promote drought induction of flower buds. About 60 to 70 days of moderate water stress are necessary to provide an economic crop level. On the negative side, excessive drought would reduce tree productivity and make irrigation essential for citrus or other crop production. With much lower rainfall insufficient would lead to depleted underground or river water needed for irrigation.

A possible additional change in climate due to global warming and increased ocean temperatures is an increase in the frequency and intensity of hurricanes. This could increase fruit losses and tree damage to an unacceptable level. After the 2004 hurricanes in Florida, trees apparently have required 3 years to recover to a normal production level. Most Florida citrus areas were exposed to 2 or 3 hurricanes in that year and some areas to another hurricane in 2005. Almost all areas have been slow to recover with a good bloom occurring only after the 2006-07 winter. This is in spite of leaf canopy looking reasonable for the last 2 years.

While hurricanes can reduce current crop and future potential, frequent tropical storms over the Caribbean could increase rainfall and reduce the chances of this area becoming dryer than normal. However, the rainy season might shift to slightly later dates resembling the hurricane season. If flowering were to become weaker in the spring then a warmer and changed rainy pattern

could easily lead to a 2 flowering – 2 crop per year pattern as occurs further south in areas like Belize. More rain in late summer and fall would also result in diluted soluble solids.

Overall, global warming, if it occurs at the magnitude projected can be expected to have a profound, primarily negative, effect on citrus production in the Caribbean. If land is available, production would logically move north depending on where the new freeze line is established. This might be in southern or mid-Georgia. Lower elevations in Mexico could be true tropical climates with little or no winter cool temperature induction.

Although this dooms-day scenario is not very promising for the future of citrus production in the Caribbean, global warming is not going to be at its worse for several years. It will likely be in the next generation, at least, before the full effects of global warming occur. As scientist work out the real relationship between other climate changes and global warming, we will have to adjust citrus production practices to a changing environment,