# An examination of the impacts of climate change variables on growth and photosynthesis in *Theobroma cacao* L.

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## Abstract

Climate change predictions suggest that cacao agriculture will change into the future. This study examines the effects of climate variables (elevated $CO_2$ and water deficit) on growth and photosynthesis of cacao seedlings (var. Amelonado) and older clonally propagated genotypes (CL 19/10, ICS 1, IMC 47, Pound 7/B, SCA 6 and SPEC 54/1). It also identifies some of the molecular mechanisms regulating stomatal development in cacao. Elevated $CO_2$ had a positive impact on a number of photosynthetic parameters including light saturated photosynthesis, quantum efficiency and intrinsic water-use efficiency. Genetic variation was also identified in a number of parameters. Biomass production, leaf area and stem diameter were all enhanced in seedlings grown at elevated $CO_2$. The growth increase in response to elevated $CO_2$ was stronger in seedlings than older trees. Water deficit enhanced the positive effect of elevated $CO_2$ on iWUE in older trees, but failed to do so in seedlings due to higher $g_s$, likely caused by greater stomatal production at elevated $CO_2$. There was a significant interaction between $CO_2$ and water stress in relation to quantum efficiency, however, the effect varied for seedlings and older trees. Stomatal production occurred during the period of rapid leaf expansion in cacao. The protein sequences of stomatal development genes *SPCH, MUTE* and *FAMA* in cacao shared a high degree of conservation with the equivalent sequences of *Arabidopsis*. *Cis*-regulatory domains in the promoter regions suggest guard cell-specific and leaf-specific expression of these genes. The expression pattern of *FAMA* suggests this gene functions in regulating the later stages of stomatal development in cacao. Further research is required to determine if increased growth and photosynthesis will impact on pod production in cacao. Elevated $CO_2$ studies, in combination with other environmental variables, are required to fully understand the impact a changing climate will have on future cacao farming.