Rubber tree ecophysiology and climate change: What do we know?

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Extended abstract

The first and most direct climatic factor that will affect rubber cultivation is the rise in mean air temperature. This rise, well predicted by global climate scenarios synthetized by the Intergovernmental Panel on Climate Change (IPCC), will induce changes in rainfall patterns and evaporative demand. It will also trigger more frequent heat waves, storms and floods. Such extreme events, together with an irregular and unpredictable climate (particularly rain patterns) will increase risks as a whole for rubber cultivation, as presented in other interventions of this workshop.

Here we focus on the direct effects of mean air temperature and water stress on rubber tree functions and latex yield.

The first requirement is to forecast with enough confidence and precision the future climate in all the natural rubber producing areas. The global climate scenarios will translate differently locally, under the influence of sea streams, landforms, etc. Reliable methodologies for such downscaling work are available and some good results are already published, for instance in Xishuangbanna Dai Autonomous Prefecture, Yunnan, China (Zomer et al. 2014). However, this has to be generalized or updated.

Regarding the direct effects of climate change on rubber tree physiology, we know very little and significant research efforts at international level are necessary to fill the gaps.

At leaf scale, we know that carbon assimilation by photosynthesis will decline sharply above the optimum of 29°C. We are able to forecast the main parameters (V_{cmax} and J_{max}) used for modelling photosynthetic activity under future air temperature (Kositsup et al. 2009). However, to forecast the whole tree and whole plantation carbon assimilation, we need much more knowledge about stomatal conductance, regulations at canopy scale and phenology. It is likely that under higher temperatures, actual photosynthesis will be reduced through lower stomatal conductance and that leaf will live shorter.

The ways forward are:
- to analyse the CO_2 and water exchanges measured at plot scale by eddy covariance flux towers (Giambelluca et al. 2016; Chayawat et al. 2019) together with accurate microclimatic data over several years. Such analyses are undergoing to draw equations linking temperature to net photosynthesis (NEE), ecosystem respiration, gross primary production (GPP, biomass accumulation) and evapotranspiration (water use).
- To include such equations, specifically calibrated for rubber trees, into functional models such as MAESPA (Duursma and Medlyn 2012) to simulate future carbon

assimilation, carbon and water balance and water use efficiency (WUE) of rubber plantations under different climatic scenarios.
- To improve in plantation models (e.g. LUCIA, Yang et al. 2019) the functions linking primary productivity and climate to latex yield through equations that will include plantation management options, particularly regarding tapping systems.

A key point is the allocation of carbon within the tree, as latex yield competes with growth, maintenance and reserves. Isotopic methodologies are now available for field experiments and the first results (Duangnam et al. 2020) show the importance of carbohydrate reserves (starch located in the trunk wood) to sustain latex regeneration.

A key research topic is the interactions between climate changes and tapping systems. Low tapping frequencies will likely develop to cope with the shortage of skilled manpower (Gohet et al. 2016). As compared to current systems, such reduced frequencies will induce less regular patterns of latex flow and carbon demand for latex regeneration (peak at each tapping day, followed by long inactive periods). We have to assess how these systems will behave under climate change. For instance, in addition to the issues linked to irregular rainfall patterns described in other presentations, higher temperature will likely reduce latex flow and therefore latex per tapping day. Higher predicted night temperature may be particularly detrimental (Yu et al. 2014).

There is more available knowledge about water stress thanks to the numerous studies about the adaptation to drier conditions in marginal areas, mainly in India and north-eastern Thailand (review by Carr 2012). However, most studies focused on drought, whereas climate change may as well induce excesses of water and waterlogging issues that are poorly documented.

Recent works allowed the effects of air dryness (higher water pressure deficit due to higher temperature) to be better distinguished from the lack of water resources in the soil. Isarangkooll et al. (2011) showed that even

when there is enough soil water, rubber trees close their stomata and limit their transpiration when the evaporative demand is too high.

This has important implications. First, it shows that current water use and therefore the impact of rubber tree plantations on water resources are overestimated in many published studies and models (Guardiola et al. 2008), second that rubber tree tend to avoid water loss and be more tolerant to water stress than expected from its equatorial origin. However, that also means that rubber tree growth will be limited in such conditions, therefore prolonging the duration of the immature phase and finally the yield potential.

Together, this shows the importance to better understand rubber tree hydraulics, water regulation and growth patterns. Recent work in Thailand showed that there is a promising genetic variability among the existing commercial clones for breeding drought tolerant clones (Isarangkool Na Ayutthaya et al. 2017).

To conclude, there are risks of adverse effects of climate change on rubber tree growth, survival and yield and little scientific knowledge to understand the physiological responses of the trees to such conditions. Improving the functions describing the ecophysiology of the rubber trees (carbon assimilation, water use, growth, latex flow and latex regeneration) in integrative models is a priority and could constitute a relevant cooperative research project.

Key words: High air temperature, water stress, photosynthesis, hydraulics, modelling.

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