Worldwide climate typologies of rubber tree cultivation: Risks and opportunities linked to climate change

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Extended abstract

Natural rubber (NR) is a “green” substitute to petrol-made elastomers, representing in 2020 about 47% of the global elastomer market. It is a strategic raw material as there is currently no credible or sustainable substitution by other compounds, due to specific adhesive properties and high resistance to physical constraints (pressure, heat, etc.). These specific properties make natural rubber an essential industrial product used in the tyre industry (car radial tyres, truck/plane/bulldozers tyres) as well as for anti-vibration systems, anti-seismic equipment and medical equipment. Actually, a shortage of natural rubber would result in a civilization shock driven by freight and transport disruption. As a consequence, adaptation in case of changes in climatic production conditions is a must.

The climate marginality due to warm temperature has until now never been described, as rubber trees have until now never been planted in areas where average mean annual temperatures are above 28°C. Most of the current rubber plantations are localized in areas where mean annual temperature ranges from 26 to 28°C. This raises uncertainty about the future, in a context where temperatures are expected to increase by 2°C–3°C following IPCC scenarios. At the moment, almost nothing is known about the growth and adaptation of rubber clones under these upcoming high temperatures. Even less is known about the impact on the yield under those conditions of increased temperatures. Latex flow after tapping (duration of flow especially) is linked to internal turgor pressure in the latex vessels, and this is the reason why all rubber planters tap at night or in the early morning, when the daily temperature is the lowest and turgor pressure is the highest. What will happen if the temperature rises by 2°C or 3°C at the time of tapping is totally unknown. Increases in air temperature will also lead to higher vapor pressure deficit (VPD), and altered stomatal conductance, tree transpiration and water status. Changes in temperatures will also affect photosynthesis, respiration, carbon allocations, and the physiology of the latex vessels. Some knowledge is available at leaf scale (Kositsup et al. 2009) but needs to be integrated at tree and plot scale. As the latex production totally depends on carbohydrate availability and tree water status (latex itself is composed of about 60%–65% of water, as a cytoplasm), there are large uncertainties. As other aspects linked to climate change (rainfall amount and distribution, frequency of extreme events as typhoons, possible development of new diseases/pests, increases in atmospheric CO_2 concentration, etc.) may also strongly impact latex production, they have to be anticipated by ad hoc research. Moreover, changes in temperature and rainfall conditions due to climate change can clearly modify the epidemiology of diseases

(appearance and outbreak of new diseases). However, it is yet too early to assert that the recent development of *Pestalotiopsis* disease, which emerged in South Sumatra in 2018 and thereafter spread to northern Sumatra, Malaysia, southern Thailand, Sri Lanka and India, is actually linked to climate change or not. This assessment will require observational and experimental research along climatic gradients, as well as modelling work under current or simulated IPCC climate scenarios to account for interactions between climate, soil conditions (particularly soil texture, depth and fertility), and agricultural practices.

Current rubber-growing areas can be classified in a four-legged climatic typology (Gohet et al. 2015):
- **Class 1**: Traditional areas (warm/humid): temperature 25°C–28°C, annual rainfall above 1500 mm. Most Asian and African rubber production areas.
- No or only limited climatic limitation for rubber growth and production
- **Class 2**: Marginality warm/dry: temperature 25°C–28°C, annual rainfall 1100–1500 mm (Esan in Thailand, north-western Cambodia, Nzi Comoue in Côte d'Ivoire).
- Climatic limitation for rubber growth and production due mainly to water stress.
- **Class 3**: Marginality cold/humid: temperature 23°C–25°C, annual rainfall above 1500 mm: (northern Thailand, Laos, Yunnan, Hainan, southern Brazil, Gabon, south-eastern Cameroon)
- Climatic limitation for rubber growth and production due mainly to cold temperature, without water stress.
- **Class 4**: Marginality cold/dry: temperature 23°C–25°C, annual rainfall 1100–1500 mm (Mato Grosso, Brazil)
- These scarce areas are the ones presenting the current highest climatic incidence on rubber growth and production, as cold temperature and water stress are found together.

The complexity of climate change impact is that rubber cultivation marginality is mainly determined by two rather independent climatic factors: temperature and rainfall. However, it can be anticipated that overall increases in temperatures induce a risk, or at least uncertainty, in climate classes 1 and 2. The sustainability of rubber production in such areas will depend on the concurrent evolution of rainfall. In this context, the areas of class 2 are likely to be the first affected if temperatures higher than 28°C are confirmed as detrimental to rubber growth and production. Increases in temperatures in the class 2 areas (warm and dry) might also exacerbate water stress due to increased vapor pressure deficit (VPD). By contrast, plantations status in areas with current cold marginality (classes 3 and 4) might improve under climate change. Class 3 areas (cold and humid) would conversely very probably become the best areas for rubber cultivation if temperatures increase by 2°C–3°C by 2050. This might be a possible cause for land use change and it should be very closely monitored to avoid future land grabbing and deforestation, as these areas are currently still covered by forests.

However, up to now, these likely impacts of climatic changes are just theoretical as the actual effects of increased mean temperature above 28°C on rubber production and growth have not yet been observed, studied or modelled as there has never been rubber planting in such conditions. Maybe the rubber trees will be adaptable to it, maybe not. That is the question, and there is anyway a risk, which must be evaluated through research and modelling, regarding clonal adaptation and incidence on growth and production. Modelling approaches developed for similar tropical plantations should be adapted to rubber (Vezy et al. 2020). Research has been carried out to model the incidence on growth and production of cold climate (temperature 23°C–25°C) and dry climate (increased length of dry season from four to six months; Gohet et al. 2015). Under climate change, water stress is expected to increase in these areas, which will probably strongly affect rubber production, especially in areas where the soil is not deep.

Setting up multidisciplinary research programs (associating breeding, physiology, ecophysiology, technology, climatology, bioclimatology and socioeconomics) appears as a priority to guarantee the sustainability of the NR supply chain in this context of global climatic change, in order to:

- Fill the numerous knowledge gaps and improve the downscaling and reliability of forecasts at local/regional levels;
- Adapt the good agricultural practices (GAPs) to the new growing conditions (technical packages);
- Generalize the adoption of the climate-smart agriculture (CSA) concept for climate change adaptation and mitigation.
- Orient decision making and planting policies on scientifically sound criteria.

Together with other global challenges (labour shortage risk), it should be the main goal of natural rubber research in the next decades.

Key words: climate change, temperature, rainfall, natural rubber, climate typology, good agricultural practices (GAP), growth, production, physiology, ecophysiology, climate smart agriculture (CSA).

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