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Mini Review

Plant Ecophysiolomics to face the challenges of global change

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Abstract

As consequence of global change, there has been an intensification of syndromes such as land desertification in several regions of the world. Plant functioning is threatened by this scenario. Given its importance for sustaining mostly all terrestrial life, a renewed interest has risen in studying the effects of global change over plant functioning, particularly for its role in ecosystem energy fluxes, and as the basis for food, fiber, biofuels and other products used by humans. This mini review attempts to draw attention on the benefits of study the effects of global change over plant functioning under a comprehensive approach. Ecophysiolomics, the merge of Plant Physiology, Ecophysiology and Omics, is an emerging field helping to elucidate the mechanisms, from molecular to population and community levels, underlying plant growth and development, against the effects of global change. By integrating and merging different approaches such as Ecophysiolomics, we will maximize not only our understanding of plant-to-ecosystem resilience, but also, the support and advice for policy makers and governments to better manage the threats and challenges of global change.

The ongoing global change, i.e., global climate variability and extremes plus the anthropogenic intervention on the planetary biogeochemical processes, is producing profound changes in the biosphere with an unprecedented speed. Worldwide, the scientific community has presented strong evidence that global change is having profound impacts on global economy, natural resources, and human health [1,2]. Particularly among plant biologists, there is a consensus that the effects of the current global change have imposed rapid and major spatio-temporal shifts over a number of environmental variables that will have profound impacts on the physiological and metabolic functioning of plants [3-5]. This is a matter of global concern considering that plants are the key stone for the energy fluxes in mostly all terrestrial ecosystems (i.e., primary productivity), and the basis for food, fiber, biofuels and other products used by humans [6-9]. Given the importance of plants for sustaining terrestrial life and ecosystems equilibrium, it is pivotal to maximize our understanding of plant-to-ecosystem resilience against the threats of global change.

Being sessile organisms, plants respond to the environmental heterogeneity and stressors through a suite

of complex mechanisms, that goes from gene regulation to ecological interactions. To decipher these responses has long been a priority among plant scientist. Woodward [10] presented a visionary review that pointed out the limitations and challenges in trying to predict plant responses to global environmental change. A take home message from Woodward's paper was that by using a multi-scale and multi-approach experiments and observations, the best will be the opportunity to predict the responses of plant-community-ecosystem to the effects of global change. During the last decade, an increasing number of multidisciplinary projects (e.g. TRY Plant Trait Database) have provided important advances in understanding plant responses and adaptation to different components of global change. The ongoing technological and scientific advances have contributed to disentangle the responses of plants under different stressors. Emerging interdisciplinary approaches such as paleo-ecophysiology, genomic ecology, ecological evolutionary development, etc. are filling important gaps of knowledge [10-13]. However, even these emerging fields has developed mostly independent from each other, limiting comprehensive understanding of plant responses against the risk of global change and the amelioration of its



negative effects.

One of the main syndromes derived from global change is the intensification of dry land expansion (reaching up to date 3.6 billion ha. worldwide; source <https://www.un.org/sustainabledevelopment/biodiversity/>) which is expected to exacerbate water scarcity, land degradation and desertification, especially in arid and semi-arid regions [14,15]. Moreover, being agriculture the main economic activity in the most sensitive regions to global change effects, such as the semi-arid, population welfare relies primarily on precipitation and temperature. Thus, even small variations in the seasonal and inter-annual patterns of temperature and precipitation may have catastrophic effects over plant performance and yield in both natural and agricultural systems. Dry land expansion brings an increase in frequency and intensity of drought, being along with heat stress, major constraints for processes that sustain terrestrial primary productivity, such as photosynthesis. Physiologically, the process of photosynthesis is one of the most sensitive processes to thermal and drought stress [16,17]. Specifically, high temperatures affect the carboxylation efficiency and produce the impairment of the electron transport rate [18]. Drought, by its hand, lead to low water availability for plants, which is the most important abiotic factor limiting photosynthesis, and consequently, plant growth and yield [19]. Thus, no matter what the real scenario of global change we will face, all of them impose significant threats to ecosystem protection and food security. Far from being a daunting panorama, plant scientists have a great opportunity for conducting research involving holistic-based analysis with multiple tools to better understand plant functioning responses to stressful conditions, especially in those regions most sensitive to global change.

Incorporating an Ecophysiolomics approach to better understand plant functioning and responses under a global changing world

Plant Physiology, Plant Ecophysiology, and Omics are disciplines advocated to the study of plant mechanisms involved in the responses to internal and external cues, i.e., plant functioning. Plant functioning include all the components underlying plant growth and development, from molecular to the whole plant and it surrounding environment. Hence, it is reasonable to think about merging these disciplines to enhance the predictions about plant responses to global change, and even better, enhance the methodologies to mitigate the negative effects in both, natural and agricultural systems. Flexas and Gago [20] addressed this issue in an excellent review about the common pathways of plant ecophysiology and the different omics approaches. The authors suggest that, these disciplines (Plant Ecophysiology and the Omics = Ecophysiolomics) must be integrated for a real comprehensive understanding of plant functioning and responses, from molecular interactions to a population and community level. So far, there are still large gaps to fill about the gene regulatory networks underlying the transcriptomic, metabolomic and physiological responses of plants against the components of global change, such as drought, heat stress, eutrophication, soil degradation, etc., and

much less against their combined effects. Recent advances in high-throughput large-scale analytical methods combining the multidisciplinary approaches mentioned above, have enabled to discover new genetics and biosynthetic pathways for important plant-based processes and metabolites [21,22]. These type of multidisciplinary research approaches are providing frameworks for better understanding the mechanisms that govern plant and crop responses to environmental cues [23–25], with insights into molecules that can be used for crop improvement projects [26]. Given the progressing scenario of global change, the reasoning of Flexas and Gago [20] makes more and more sense. Since the present and future environmental, socio-ecological, and economic vulnerability and adaptation-capacity of the terrestrial ecosystems depends largely on plants, it is imperative to address the effects of global change under a comprehensive, interdisciplinary approach. Finally, global change and human disasters, such as pandemics, reveal the fragility of our ecosystems. Given the importance of plants for sustaining terrestrial life and ecosystems equilibrium, integrating different approaches such as Ecophysiolomics, will maximize not only our understanding of plant-to-ecosystem resilience, but also, the support and advice for policy makers and governments to better manage the threats and challenges of global change.

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