PhD School on Agriculture, Environment and Bioenergy

(http://sites.unimi.it/dottorato_aab/)

(XL cycle, 2024-27)

Project draft

1.Field of interest

*Indicare **il/i** settore/i scientifico disciplinari:*

AGRI-02/B - Orticoltura e floricoltura (ex AGR04)

2.Project title

Innovative lighting systems in horticultural crop production: light-plant interaction, quality, physiology, sustainability.

3.Tutor: Giacomo Cocetta

co-tutor/s: Antonio Ferrante

4.Relevance of the topic and state of the art:

Today, artificial lighting systems serve as a critical tool for modulating crop responses in terms of yield and quality. By manipulating light, it is possible to stimulate plant growth and photosynthesis, as well as induce specific responses that can lead to the synthesis of valuable compounds and the activation of specific metabolic pathways through spectral modification. Additionally, it is possible to control and regulate crucial phenomena such as flowering, allowing for the precise timing of this vital developmental stage. Innovative and cutting-edge applications of artificial lighting extend even into the postharvest phase, thanks to the unique operational characteristics of LED lights, such as low heat emission, compact size, and the capability to operate with monochromatic lights. Understanding the light-plant interaction is a prerequisite for any type of experimentation, whether in a controlled environment or in open fields. In the latter case, modern agricultural practices are increasingly incorporating energy production systems (e.g., photovoltaic panels) installed over cultivated fields. This integration leads to alterations in the availability of natural light for crop growth, necessitating a thorough understanding of the mechanisms and responses of specific crops to characterize and optimize these new production systems. Such knowledge is essential to harness the potential of these systems effectively and to mitigate any adverse impacts on crop performance.

5.Layout of the project (draft)

5.1. Materials & Methods:

The experimental activities will involve the evaluation of horticultural crops (e.g., arugula, lettuce, spinach) and medicinal plants (e.g., mint, woad, knotweed), cultivated both in open fields and controlled environments, under various lighting conditions. The case studies conducted in controlled environments will incorporate the use of innovative lighting systems (LEDs) with specific light quality or intensity and advanced applications (UV-B, pulsed light) to achieve high-quality products without compromising yield and system

productivity. Additionally, field trials will be set up in tunnels where artificial light will be provided as supplement to natural sunlight. These evaluations aim to better understand the responses of the crops to different lighting regimes by studying physiological parameters measured *in vivo* during cultivation, followed by laboratory analyses focusing on qualitative and physiological parameters. Moreover, in the most promising cases, advanced techniques will be employed to elucidate the mechanisms and modes of action underlying the agronomic observations. This will be accomplished through transcriptomic and metabolomic analyses. Specific analytical techniques will also be developed and used to identify and quantify specific metabolites (HPLC) and the expression of key genes associated with these metabolites (RT-PCR). For indoor systems, measurements of electrical energy consumption will be conducted, and the obtained data will be correlated with system productivity to monitor resource use efficiency, ultimately assessing the economic sustainability of the tested systems.

5.2. Schedule and major steps (3 years):

The project will be structured as follows:
First Year:
- Conduct a comprehensive literature review and plan preliminary experiments (approximately 6 months).
- Set up initial experimental trials in both indoor and open field conditions.

Second Year:
- Execute experiments and evaluate various systems (indoor and open field) on different horticultural and medicinal crops.
- Conduct *in vivo* and laboratory assessments, including physiological (light use efficiency and leaf gas exchanges), biochemical (leaf pigments, antioxidant compounds, sugars, and nitrates) and agronomic evaluations (growth indexes).
- Abroad research period of 3-6 months.

Third Year:
- Identify the most promising system/plant combination and perform in-depth analyses using transcriptomics and metabolomics.
- Write the thesis and prepare articles for publication.

6. Available funds (to support research):

Funding will be available to support the research, sourced from both specific grants focused on the theme of lighting and from free funds.

7. Co-Financing (to support the bourse):

NO

8. Literature:

1. Cocetta, G., Casciani, D., Bulgari, R., Musante, F., Kołton, A., Rossi, M., & Ferrante, A. (2017). Light use efficiency for vegetables production in protected and indoor environments. The European Physical Journal Plus, 132, 1-15.
2. Loconsole, D., Cocetta, G., Santoro, P., & Ferrante, A. (2019). Optimization of LED lighting and quality evaluation of romaine lettuce grown in an innovative indoor cultivation system. Sustainability, 11(3), 841.
3. Ali, A., Santoro, P., Mori, J., Ferrante, A., & Cocetta, G. (2023). Effect of UV-B elicitation on spearmint's (Mentha spicata L.) morpho-physiological traits and secondary metabolites production. Plant Growth Regulation, 1-14.

4. Ali, A., Santoro, P., Ferrante, A., & Cocetta, G. (2023). Investigating pulsed LED effectiveness as an alternative to continuous LED through morpho-physiological evaluation of baby leaf lettuce (Lactuca sativa L. var. Acephala). South African Journal of Botany, 160, 560-570.
5. Ali, A., Franzoni, G., Petrini, A., Santoro, P., Mori, J., Ferrante, A., & Cocetta, G. (2023). Investigating physiological responses of Wild Rocket subjected to artificial Ultraviolet B irradiation. Scientia Horticulturae, 322, 112415.
6. Ali, A., Cavallaro, V., Santoro, P., Mori, J., Ferrante, A., & Cocetta, G. (2024). Quality and physiological evaluation of tomato subjected to different supplemental lighting systems. Scientia Horticulturae, 323, 112469.