Investigation of seed germination, rooting and growth technologies of industrial hemp (*Cannabis sativa* L., Cannabaceae). Morphological and physiological characteristics

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ABSTRACT

This doctoral dissertation investigates critical stages of the production cycle of industrial hemp (*Cannabis sativa* L.), focusing on seed germination, clonal propagation, canopy architecture management, and plant responses to water stress. The research was structured into four experimental sections aiming to evaluate the physiological responses, agronomic performance, and phytochemical composition of the plant under different environmental and cultivation conditions.

The first experiment examined the germination response of the cultivar 'Santhica 70' under different temperature regimes, relative humidity levels, and gibberellic acid (GA_3) concentrations. Temperature was identified as the dominant factor regulating germination. The highest final germination percentage was achieved at 20 °C, whereas higher temperatures accelerated germination without improving final germination success. Relative humidity mainly affected the final germination percentage, while GA_3 exerted a limited but favorable effect on germination kinetics.

The second experiment focused on the rooting performance of cuttings from the cultivars 'Enectaliana' and 'Santhica 70' in an aeroponic system and a peat-perlite substrate system. Aeroponics significantly enhanced rooting initiation, root number, root length, and both fresh and dry root biomass. The findings demonstrate that aeroponic propagation constitutes an efficient technology for producing uniform and high-quality propagation material.

The third experiment investigated the effects of topping on plant architecture, physiology, and phytochemical composition. Topping, particularly at the 4th node, reduced plant height, enhanced lateral branching, increased aboveground biomass, and improved photosynthetic parameters. Furthermore, it influenced cannabinoid

accumulation, increasing CBD content in ‘Enectaliana’ and CBG content in ‘Santhica 70’ without negatively affecting biomass production.

The fourth experiment evaluated the effects of deficit irrigation and plant growth-promoting microorganisms (PGPM) on the physiology, morphology, and biochemical profile of *C. sativa*. Water deficit significantly reduced photosynthetic activity, stomatal conductance, chlorophyll content, and biomass accumulation, while increasing the concentration of acidic cannabinoids such as CBDA, THCA, and CBCA. PGPM application mainly contributed to maintaining physiological stability under stress conditions but did not significantly increase biomass production or directly alter cannabinoid profiles.

Overall, the dissertation demonstrates that industrial hemp exhibits high physiological plasticity, while productivity and phytochemical quality strongly depend on the timing and intensity of agronomic interventions. Temperature management, propagation technology, topping practices, irrigation strategies, and PGPM application can be combined to develop integrated and scientifically optimized cultivation protocols. This work contributes to the transition from empirical cultivation practices toward targeted and evidence-based management strategies for *Cannabis sativa* L., adapted to the requirements of modern, sustainable, and quality-oriented agriculture.

Scientific area: Plant Physiology and Agronomy of Industrial Hemp

Keywords: Industrial hemp, *Cannabis sativa* L., Seed germination, Clonal propagation, Aeroponics, Rooting of cuttings, Topping, Photosynthesis, Water stress, Deficit irrigation, Plant growth-promoting microorganisms (PGPM), Cannabinoids, Cannabidiol (CBD), Cannabigerol (CBG), Secondary metabolism, Phytochemical composition.