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HYDROPONIC CULTIVATION OF LETTUCE AS A SUSTAINABLE APPROACH TO REDUCING SOIL-BORNE DISEASES

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Sustainable vegetable production requires innovative cultivation technologies that improve crop productivity while reducing environmental impact and the incidence of plant diseases. Hydroponic cultivation has emerged as an efficient alternative to conventional soil-based systems by providing precise control of plant nutrition and growing conditions. Lettuce (*Lactuca sativa* L.) is one of the most economically important leafy vegetables cultivated in hydroponic systems because of its short production cycle and high commercial value. The aim of this study was to evaluate the potential of hydroponic cultivation as a sustainable strategy for reducing soil-borne diseases and improving the growth and quality of lettuce under protected cultivation.

The study was conducted using a nutrient film technique (NFT) hydroponic system under controlled greenhouse conditions. Lettuce plants were cultivated using a balanced nutrient solution with a pH maintained between 5.8 and 6.2 and an electrical conductivity of 1.4–1.8 mS cm^{-1}. Greenhouse temperature, relative humidity, and light conditions were regulated to ensure optimal plant development. Plant height, number of leaves, fresh biomass, root development, and visual quality were evaluated during the growing period. Particular attention was given to the occurrence of soil-borne diseases and the overall phytosanitary condition of the plants.

Hydroponic cultivation ensured uniform plant development and intensive vegetative growth throughout the production cycle. The absence of soil substantially reduced the likelihood of infection by major soil-borne pathogens, including *Fusarium* spp., *Pythium* spp., and *Rhizoctonia* spp., which are responsible for root rot and seedling diseases in conventional production systems. Healthy root development and continuous nutrient availability promoted efficient uptake of mineral elements and enhanced biomass accumulation. In addition, hydroponic cultivation reduced water consumption through nutrient solution recirculation and minimized nutrient losses

to the environment. The controlled cultivation environment also decreased the need for chemical plant protection products and facilitated the implementation of integrated pest and disease management practices. The obtained observations indicate that hydroponic production contributes to higher product uniformity, improved market quality, and more sustainable use of natural resources.

Hydroponic cultivation of lettuce is an effective and environmentally sustainable production technology that supports modern plant protection strategies. The elimination of direct soil contact significantly decreases the risk of soil-borne diseases while promoting healthy plant growth and efficient resource utilization. The integration of hydroponic systems into greenhouse vegetable production can reduce pesticide dependence, improve crop quality, and enhance the sustainability of agricultural production. Further studies should investigate the combined use of hydroponic systems with biological control agents and beneficial microorganisms to strengthen integrated plant protection programs.

Keywords: hydroponics, lettuce, plant protection, soil-borne diseases, greenhouse production, NFT system, sustainable agriculture.