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EFFECTS OF TEMPORARY SOIL WATER LOGGING ON AGRICULTURAL CROP PERFORMANCE: A REVIEW

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Abstract: *Temporary soil waterlogging is an increasingly significant environmental stress factor affecting agricultural crop production worldwide. Climate change, with its intensified and irregular precipitation patterns, has amplified the frequency and extent of short-term flooding events, particularly in lowland and poorly drained agricultural regions. Such water excess not only influences the growth and productivity of cereals such as wheat (*Triticum aestivum* L.), but also impacts a wide range of other field crops including oilseeds, legumes, and vegetables. Prolonged or repeated waterlogging disrupts the soil–plant–atmosphere continuum, leading to oxygen depletion, reduced nutrient availability, and impaired root functionality. This review summarizes current knowledge on the effects of periodic soil water excess on soil–plant interactions, emphasizing the physiological, morphological, and yield responses of major agricultural species. By integrating findings from diverse cropping systems, the paper aims to highlight both the common stress mechanisms and crop-specific adaptation strategies that determine plant performance under transient flooding conditions*

Keywords: water logging, excess water stress, climate change, flooding tolerance, sustainable agriculture

• Introduction

Hungary's lowland areas are highly exposed to inland excess water because of flat topography, fine-textured soils and often inadequate drainage. Inland water forms when precipitation, snowmelt or groundwater cannot infiltrate or run off, leading to temporary surface water coverage and saturated soil. Besides natural factors, land use, soil compaction and the condition of drainage systems strongly influence the extent and duration of waterlogging. Climate change, with more frequent intense rainfall events and milder, wetter winters, is expected to increase the occurrence of inland water, not only in spring but also in autumn and winter. Waterlogging deteriorates seedbed quality, delays sowing, impairs germination and reduces vegetative growth, finally leading to substantial yield losses and making inland water both a water management and a complex agro-ecological problem

Soil–plant interactions under waterlogging

Temporary waterlogging rapidly fills soil pores with water, reducing air-filled porosity and strongly restricting gas diffusion. As oxygen supply becomes insufficient, the root zone shifts from aerobic to hypoxic or anoxic conditions. This causes a decline in root respiration, leads to the accumulation of toxic metabolites and may result in cell death in sensitive root tissues. Redox potential decreases, altering nutrient forms and availability: denitrification and leaching increase nitrogen losses, while reduced forms of iron and manganese may reach phytotoxic concentrations. At the same time, waterlogged soils often show slower decomposition of crop residues but accelerated mobilization of certain nutrients. Microbial communities are reorganized in favour of anaerobic and facultative anaerobic organisms, further modifying nutrient cycling and soil structure, and thereby indirectly affecting plant growth and yield.

Plant physiological responses to temporary waterlogging

Temporary waterlogging represents a complex stress that first affects roots, then propagates to the whole plant. Oxygen deficiency in the rhizosphere reduces ATP production and impairs active ion uptake, disturbing nutrient balance and water relations. Stomatal conductance decreases, limiting CO₂ assimilation, while chlorophyll degradation and damage to the photosynthetic apparatus reduce photosynthetic efficiency. Under prolonged stress, reactive oxygen species accumulate, causing oxidative damage to membranes and cellular components. Plants trigger adaptive responses such as the formation of aerenchyma and adventitious roots in less-saturated soil layers, changes in root architecture and altered allocation of assimilates. Hormonal signalling—especially via ethylene, abscisic acid and cytokinins—plays a key role in coordinating these responses and in regulating shoot growth, leaf senescence and recovery after the water has drained.

The response of winter wheat (*Triticum aestivum* L.) to waterlogging stress

Winter wheat is among the field crops most sensitive to temporary waterlogging, and its response is strongly stage-dependent. Waterlogging during tillering reduces tiller formation and survival, leading to fewer productive spikes per unit area. If stress occurs around stem elongation or flowering, it interferes with pollination and grain set, thus reducing the number of grains per spike. Limited photosynthesis and impaired assimilate transport under hypoxic conditions also lower thousand-kernel weight. Yield losses increase with the duration and depth of waterlogging; periods longer than 7–14 days often cause severe root damage, leaf chlorosis and premature senescence. Genotypes differ substantially in tolerance, which is linked to traits such as efficient aerenchyma formation, maintenance of photosynthetic activity, stronger antioxidant defence and better recovery after the flooding event.

• Conclusions

Temporary soil waterlogging is an increasingly important constraint in agricultural production, especially in lowland regions with poor natural drainage and ageing water infrastructure. It simultaneously alters soil physical conditions, redox status, nutrient cycling and microbial communities, while causing profound physiological and morphological stress responses in crops. Winter wheat is particularly vulnerable, with waterlogging at tillering and flowering leading to major yield losses through reduced spike number, grain set and kernel weight. Although plants possess adaptive mechanisms, their effectiveness is highly genotype- and stage-dependent. Sustainable mitigation of waterlogging impacts requires integrated water management, maintenance and modernization of drainage systems, improved soil structure, and the development and dissemination of waterlogging-tolerant cultivars supported by monitoring and precision agriculture tools.