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Highland rice under changing climate: lessons learnt from field and controlled greenhouse studies

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Abstract

Rice cultivation in Nepal has been extended to altitudes of 3,000 masl, where it relies on the use of cold tolerant *Oryza sativa* japonica landraces. Depending on the altitude, these genotypes have to cope not only with low temperatures but are also exposed to high solar radiation. In addition, drought can be a critical constraint in rainfed systems of the highlands. We assessed prevailing crop management practices among highland farmers and rice genotype responses to changing climatic conditions along an altitude gradient, both under controlled conditions in the greenhouse as well as in the field in Nepal.

Initial household surveys were conducted in Jumla district, a high-altitude region in Karnali Province of Nepal, to document existing agronomic management practices and perceived constraints for highland rice production. Subsequently, multi-location varietal trials assessed the altitude-related resilience of six recommended and widely-used rice genotypes in farmer´s fields, located between 2000 and 2800 masl. Finally, greenhouse experiments in potted soils assessed the effect of seed priming with UVB radiation at 7 KJ m^{-2} hr^{-1} (simulated radiation exposure at high altitudes), on improving abiotic stress resilience. Agronomic traits (tiller numbers, plant height), stress tolerance indices (leaf flavonoid content and NDVI), as well as rice biomass and grain yield were measured.

With increasing altitude, farmers advance the time of seeding / transplanting to cope with the cold-induced extension of the phenological development. Apart from low temperatures, perceived key production constraints comprise drought, disease pressure, and labour scarcity. While the vegetative growth (tillers, plant height, biomass accumulation) was more at the warmer lower altitudes, grain yields tended to be up to 40 % higher at 2800 masl (high UVB radiation). The locally-preserved traditional genotypes outperformed modern varieties at most locations regarding grain yield (var. DBB) and grain quality attributes (var. Marshi). Seed exposure to high UVB radiation did not significantly alter drought resilience of traditional genotypes, but improved some performance attributes of modern genotypes under non-drought conditions. The possible role of UV-priming on abiotic stress resistance and an altitude-specific selection of rice genotypes will gain relevance with the ongoing expansion of high-altitude farming and warrants further studies.

Keywords: Cold tolerance, crop phenology, grain quality, *Oryza sativa*, ultraviolet radiation, UV-priming

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