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Bytes4Beets - Harnessing Wild Beet Genomics for Climate-Resilient Beets

Climate change is projected by the IPCC to raise Mediterranean temperatures by +2.2–5 °C this century, intensifying heat stress, drought, and food insecurity. These risks are acute in the Mediterranean basin, a biodiversity hotspot and vital region for European agriculture. The EU's Green Deal, Biodiversity Strategy 2030, and Common Agricultural Policy (2023–2027) highlight the urgent need for climate-resilient crops. Sugar beet (*Beta vulgaris* ssp. *vulgaris*) supplies ~20% of global sugar, with Europe producing more than half. It is both economically important and environmentally relevant, as a deep-rooted crop contributing to soil carbon sequestration. Yet modern cultivars, bred mainly for yield, are highly vulnerable to rising spring–summer temperatures that threaten root yields and seed set, especially in southern Europe. Crop wild relatives (CWRs) are underused reservoirs of adaptive traits. In the *Beta* genus, the wild ancestor *Beta vulgaris* ssp. *maritima* thrives along Italy's Adriatic–Ionian coasts, enduring the same heat stress now limiting cultivated beets. These coasts span five macroclimatic zones within a narrow latitudinal band, offering a natural gradient for studying adaptation. Italy also holds strategic importance as Europe's hub for high-quality beet seed production, itself increasingly at risk from warming. Bytes4Beets will integrate landscape genomics and haplotype-resolved pan-genomics to uncover the genetic basis of heat stress adaptation in sea beet. Through GPS-tagged collections, long-read sequencing, and genome–environment association (GEA), the project will identify adaptive alleles and prioritise donor ecotypes. It will then screen cultivated sugar, leaf, and red beet germplasm to evaluate whether these alleles are present, rare, or absent. While stopping at donor identification and allele screening, the project establishes a scalable framework for future breeding, enabling rapid integration of adaptive variation into elite lines.

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