



Tropentag, September 10-12, 2025, hybrid conference

“Reconcile land system changes
with planetary health”

Genetic adaptation in natural populations of the chocolate tree *Theobroma cacao* L.

HELMUTH E. NIEVES-ORDUÑA¹, MARKUS MÜLLER¹, OLIVER GAILING²

¹Georg-August University of Göttingen, Dept. of Forest Genetics and Forest Tree Breeding, Germany

²Georg-August University of Göttingen, Center for Integrated Breeding Res., Germany

Abstract

The understanding of genetic adaptation in tropical crops helps to identify valuable genotypes for breeding climate resilient cultivars. As a tree crop, cacao is widely cultivated in tropical regions to produce the valuable seeds that sustain the global chocolate industry. Cacao is a cash crop that provides economic benefits for smallholders (cacao producing families) of West Africa, Asia and Latin America; however, climate variability and droughts challenge sustainable cacao production. Thus, cacao breeding programmes should increase genetic diversity to address existing and future abiotic stress. Genetic-environmental association analysis helps to identify underlying alleles associated with potential adaptation traits to current and future climate challenges. A genetic-environmental association analysis was conducted using a diverse set of 157 wild accessions from across Amazonia. This study incorporated 19 bioclimatic variables, an aridity index, 15 soil characteristics, and genotypic data from 42 SNP markers. We identified a set of SNPs associated with climate and soil conditions. Cacao accessions that originated from areas with drier and hotter climates showed higher levels of homozygosity (e.g., GG genotypes for the candidate SNP for climate adaptation Tcm009s02031341) than trees originating from humid conditions. This adaptive genetic variation observed in *ex situ* cacao collections reflects local adaptation within the wide geographic distribution of the species in Amazonia. Specifically, we detected potential adaptive variation in the drier and warmer southwestern and eastern Amazon compared to the humid northwestern Amazon. In addition, these valuable genetic resources (e.g., Guiana accessions) provide novel alleles for breeding climate resilience in cultivated cacao. Breeding programmes have access to these accessions for experimental breeding through the International Cocoa Quarantine Center and the International cacao collection at CATIE in Costa Rica.

Keywords: Adaptive genetic variation, Amazonia, cacao, climate resilience, genetic resources