# Pheno-Genetics of Local Apple Varieties in Northern Region of Pakistan: A Hidden Pool of Apple Diversity?

Martin Wiehle[1], Muhammad Arslan Nawaz[2], Richard Dahlem[3], Iftikhar Alam[4], Asif Ali Khan[5], Oliver Gailing[6], Markus Müller[6], Andreas Buerkert[2]

[1] *University of Kassel, Tropenzentrum / ICDD / Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics (OPATS), Germany*

[2] *University of Kassel, Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics, Germany*

[3] *Pomologenverein, Landesgruppe Rheinland-Pfalz/Saarland/Luxemburg, Germany*

[4] *Karakoram International University, Pakistan*

[5] *Muhammad Nawaz Shareef University of Agriculture, Plant Breeding and Genetics, Pakistan*

[6] *University of Goettingen, Inst. of Forest Genetics and Forest Tree Breeding, Germany*

## Abstract

As a main fruit crop of cold temperate regions, apple (*Malus × domestica*) is traded globally. As a well documented plant cultigen, traditional germplasm in remote regions is still unexplored. In Gilgit Baltistan, Pakistan's increasing market demands for modern varieties and farmers' preference for high yields increasingly lead to the loss of local/indigenous varieties. We therefore studied local apple diversity by assessing varietal richness and diversity, arboricultural activities as well as phenotypic and genotypic characters of apple germplasm. In total, 106 individual apple trees were sampled, and 35 tree owners were interviewed from seven villages of the valleys Ishkoman and Baltistan. Alpha- and beta-diversity, dendrometric parameters, and fruit traits (qualitative and quantitative) in each village were measured. In *Malus*, such alpha- and beta-diversity measurements were conducted for the first time. Alpha diversity was higher in Baltistan, where even a wild apple relative (*Malus baccata* (L.) Borkh.) was discovered. Beta-diversity revealed three compositionally distinct clusters among villages. Calyx depth (cm), fruit weight (g), and axis pit width (cm) showed highest variability among the assessed characters, highlighting those as distinguishable fruit characters for the accessions observed. Arboricultural measures were found to be comparatively low and only a few local varieties were marketed, while most varieties were used for home consumption only. Genetic data revealed a moderate to high diversity. Considering the high varietal, phenotypic, and genetic variability, Gilgit-Baltistan appears a promising source of apple germplasm for future breeding programs. Improved management and product diversification could open up new revenue sources for farmers.

**Keywords:** Alpha-diversity, beta-diversity, Gilgit-Baltistan, varietal diversity

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**Contact Address:** Martin Wiehle, University of Kassel, Tropenzentrum / ICDD / Organic Plant Production and Agroecosystems Research in the Tropics and Subtropics (OPATS), Steinstraße 19, 37213 Witzenhausen, Germany, e-mail: wiehle@uni-kassel.de