Introgression of a Mexican highland chromosomal inversion into temperate maize accelerates flowering, promotes growth, and modulates a cell proliferation gene network.

Inv4m is a chromosomal inversion prevalent in traditional maize varieties adapted to the cold and often phosphorus-deficient Mexican highlands. Field trials throughout Mexico have shown that, when grown at high elevations, plants carrying the inversion flower faster and have greater yield than plants without it. Although growth chamber experiments indicate that *Inv4m* regulates the expression of photosynthesis-related genes in response to cold, we have yet to know the genes responsible for the adaptive effects of *Inv4m* in the field. To identify *Inv4m*-regulated genes that underlie enhanced development in the field, we bred B73-based Near Isogenic Lines (NILs) with either the inversion or the standard karyotype. We then grew these NILs in phosphorus-sufficient and deficient soils to test whether *Inv4m* contributes to local adaptation through enhanced phosphorus stress response. We measured plant reproductive and vegetative traits, phosphorus, lipids, and gene expression in the leaves. Plants showed classical responses to phosphorus starvation, including decreased phosphorus and biomass accumulation, delayed flowering, and a switch from phospholipid to glycolipid production. Notably, *Inv4m* plants flowered earlier and grew taller regardless of phosphorus availability. While increased leaf age and phosphorus deficiency resulted in genome-wide expression changes, *Inv4m*'s effects were predominantly confined to genes within the inversion. Our analyses suggest that *Inv4m* introgression modulates a trans-coexpression network enriched in cell proliferation and flower development genes, which includes DNA replication fork genes (pcna2, mcm5), histone demethylases (*jmj2*, *jmj21*), and the *FT f*lorigen homolog *zcn26*. By cross-referencing with a list of candidates from the literature, we found other *Inv4m*-regulated genes associated with flowering time and plant height. In a complementary growth chamber experiment, *Inv4m* plants showed longer shoot apical meristems than controls, supporting its effect on organ development. These findings provide insights into *Inv4m*'s role in highland adaptation through the coordinated expression of a developmental gene network.