Background: There is an increasing consensus that ecosystem processes are governed by functional identity and trait variation rather than species richness. Despite its importance, the relative effect of relevant functional traits for carbon storage has remained mostly untested in different bioclimatic regions.

Aims: In this study, different components of functional diversity such as community-weighted means of trait values (CWM), functional trait diversity (Rao's quadratic diversity), functional richness (FRi), functional evenness (FEv) and functional divergence (FDiv) were used to associate carbon content of above-ground biomass, litter and soil in four bioclimatic regions including warm and cold-steppe, semi-steppe rangelands and oak dry forest in the south-west of Iran.

Methods: Several key important traits highly associated with carbon storage including specific leaf area (SLA), height (H), leaf dry matter content, leaf nitrogen and phosphorus content (LNC and LPC), leaf longevity, wood specific gravity and life form were determined to quantify single and multiple traits that contribute to different components of plant functional diversity.

Results: The results showed that CWM of H, Chamaephyte life form, LNC and LPC were among the most important aspects of functional diversity that positively predicted carbon storage in above-ground biomass and soil. We also observed the negative association of carbon storage with FEv of LNC, Rao of LNC and FEv of multiple traits in the rangelands and the negative association of carbon storage with FDiv of SLA in the forest.

Conclusions: Our results indicate that different components of functional diversity are essential for a mechanistic understanding of the role of plant diversity for carbon storage. The negative associations between FDiv and FEv and carbon storage do not provide support for the complementarity niche hypothesis. Our results suggest that in the more functionally diverse ecosystems dominated by functionally important species with key traits, the so-called functional identity does indeed promote carbon storage, at least in these semi-arid ecosystems.