Research in China and abroad has shown that genotype × environment interaction (GEI) is the key scientific issue underlying yield instability and the differential ranking of materials across test sites. GEI reflects the fact that genotypes behave differently under different environmental conditions, and understanding this interaction is essential for predicting adaptation, identifying ideal testing environments, and selecting either broadly adapted or specifically adapted materials. In legumes, this phenomenon has been repeatedly confirmed. In Ethiopian cowpea, environments, genotypes, and GEI all had significant effects on grain yield, and GEI accounted for a larger share of variation than genotype alone, indicating strong crossover responses among test locations. In Ugandan cowpea, environment contributed the largest share of grain-yield variation, and GEI was associated with weather variables such as temperature, rainfall, and humidity as well as yield components (Mbeyagala et al., 2021). In mung bean, significant effects of genotype, environment, and GEI have also been reported, both in drought-tolerance evaluation in Bangladesh and in multi-year testing in northern Ethiopia, confirming that stable high-yielding selection requires trials over years and locations. Comparable conclusions have been reported in faba bean, lentil, Bambara groundnut, and field pea, where multi-environment experiments were necessary to identify stable, high-yielding genotypes and to distinguish widely adapted materials from those suited to specific mega-environments (Ghaffar et al., 2023). Methodologically, AMMI and GGE biplot have become the most widely used tools for this purpose because ANOVA alone can detect significance but cannot adequately resolve the non-additive structure of GEI. AMMI emphasizes additive main effects and multiplicative interaction structure, whereas GGE integrates genotype main effects with GEI and provides intuitive graphical judgment of “which-won-where,” mean-versus-stability, and environment representativeness (Mullualem et al., 2024). These methods have been applied successfully not only in legumes such as cowpea, mung bean, lentil, faba bean, Bambara groundnut, and pea, but also in other crops, where they effectively identify ideal genotypes, discriminating test sites, and mega-environment structure. At the same time, recent work suggests that stability evaluation can be strengthened by combining AMMI and GGE with complementary indices such as ASV, GSI, WAASB, WAASBY, or MTSI, especially when high yield must be balanced with multiple traits or adaptation goals. Another important insight is that the long-standing belief that legumes are inherently unreliable is overstated: long-term experiments across northern Europe showed that grain legume yields were as reliable as those of other spring-sown crops when stability was assessed appropriately, although agronomic improvement is still needed to raise both yield level and stability.

Against this background, the objective of this study is to compare the yield stability of different legume species under Zhejiang conditions and to provide an evidence base for regional species selection, variety deployment, and optimized cropping-system arrangement. More specifically, the study aims to determine whether different legume species differ significantly in mean yield and stability, to quantify the relative contributions of species effects, environment effects, and their interaction to yield variation, and to identify species or materials with either broad adaptability or specific adaptation to particular production environments. This objective follows the common logic of multi-environment crop evaluation, in which significant GEI implies the need to evaluate genotypes across diverse sites before recommendation. The technical framework therefore includes multi-environment field trials across representative ecological zones or seasons in Zhejiang, standardized measurement of grain yield and key agronomic traits, and joint statistical analysis combining analysis of variance with AMMI and GGE biplot methods. In this framework, ANOVA is used first to test the significance of species, environment, and interaction effects, while AMMI is used to partition interaction structure and assess general adaptability, and GGE biplot is used to visualize winning species, ideal genotypes, representative test sites, and possible mega-environment differentiation. Where necessary, stability indices can be introduced to integrate mean yield and stability ranking, improving the robustness of recommendation decisions. Because species differ in both production potential and functional traits, the interpretation of results should also consider their broader agronomic roles: soybean often shows high seed and protein yield, faba bean can be productive but more variable across years, white lupin may outperform other lupins in yield, and cowpea and mung bean can maintain useful forage production even under drought-related stress. Ultimately, by integrating productivity, stability, and ecological value, this study is expected to support the selection of legume species that are better suited to Zhejiang’s diverse environments and cropping systems, thereby improving farmer resilience, land-use efficiency, and the sustainable development of legume-based agriculture.