can exploit diversified, resource-efficient cropping systems. Overall, the available evidence supports comparing Zhejiang legume species through three linked dimensions: average yield level, annual fluctuation, and regional adaptation. This is the most appropriate basis for identifying legume crops that are not only productive, but also stable across Zhejiang's diverse ecological settings.

5 Comprehensive Evaluation of Yield Stability among Different Legume Crops

5.1 Stability comparison based on statistical indicators

Statistical indicators show that yield stability should be judged by combining mean performance with fluctuation measures rather than by yield alone. In soybean, high and stable yield is treated as the desired breeding target, but analyses also show that selecting only for yield can sacrifice stability, whereas selecting only for stability can reduce yield potential. For this reason, classical indicators such as the coefficient of variation, regression coefficient, deviation from regression, cultivar superiority, and rank-sum type indices are useful because they describe different aspects of adaptation and response consistency across environments.

At the same time, different indicators do not always rank materials in the same way, so their interpretation must be cautious. In lentil, several parametric and non-parametric statistics showed significant positive associations with mean yield, supporting the use of multiple indices under the dynamic stability concept (Hossain et al., 2023). By contrast, work on oat found that some commonly used statistics, including standard deviation, deviation from regression, Wricke's ecovalence, Shukla's variance, and AMMI stability value, tended to favor lower-yielding materials, while Pi, Bi, and YSI aligned better with yield improvement (Kebede et al., 2023). In addition, the traditional coefficient of variation can be misleading when variance depends systematically on mean yield, so adjusted forms of CV may provide a more defensible estimate of temporal stability.

5.2 Stability evaluation based on multi-model approaches

A more reliable comprehensive evaluation comes from multi-model analysis, especially the joint use of ANOVA, AMMI, GGE biplot, and integrated stability indices. In recent faba bean work, stability was assessed simultaneously through regression coefficient, deviation from regression, cultivar superiority, AMMI stability value, and genotype selection index, while AMMI and GGE were used to distinguish broadly adapted from specifically adapted genotypes (Wondaferew et al., 2024). Similar soybean studies also combined AMMI, GGE, WAASB, MTSI, and regression-based methods, showing that yield stability analysis is strongest when the same material is examined from several statistical perspectives rather than a single model alone (Habtegebriel and Abebe, 2023).

The value of this approach is that different models emphasize different dimensions of stability and can therefore complement one another. AMMI focuses on decomposing genotype-by-environment interaction and often identifies stable genotypes through low interaction scores, whereas GGE biplot is more useful for visualizing "which-won-where," ideal genotypes, and representative testing environments. Recent comparative analysis also showed that ASV, GGE, and GYT can produce slightly different rankings because one emphasizes interaction magnitude, another genotype-plus-interaction alignment, and another yield-trait balance, which means stability is inherently multidimensional. This interpretation is consistent with legume evidence from common bean, where AMMI, GGE, WAASB, and GSI identified overlapping but not identical stable genotypes and test environments (Estifanos et al., 2025).

5.3 Factors influencing yield stability

The main factors influencing yield stability are the environment, genotype-by-environment interaction, and the specific climatic and soil conditions that shape crop response. Across many legume trials, environment is often the largest source of variation: in field pea, environmental effects explained 59.62% of total variation and GEI explained 30.11%. In faba bean grown across different regions, the environment explained 81-93% of variation for most traits, while genotype contributed much less for many characteristics (Papastylianou et al., 2021). This means that differences in rainfall, temperature, season, and location are likely to dominate yield fluctuation among legume crops in Zhejiang.